ORDNANCE

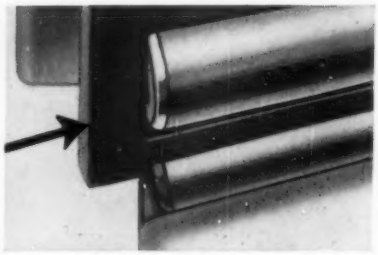
LAND · SEA · AIR

Nike Hercules

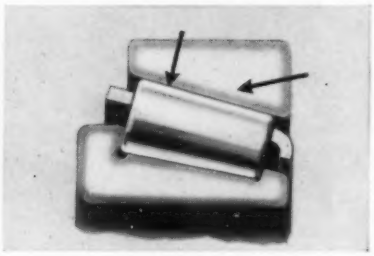
MAY-JUNE 1957

Get all these advantages . . . specify TIMKEN® tapered roller bearings

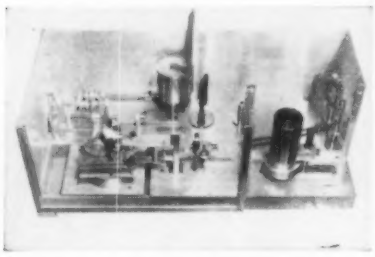
THERE ARE 27 TYPES of Timken® tapered roller bearings. This wide selection means you get the bearing design exactly suited to your job. Whatever your bearing application problem, we can help solve it.



THE SOFT STEEL CAGE used in Timken tapered roller bearings separates the rollers, keeping them spaced evenly. This prevents scuffing of the rollers, adds to the bearing life and gives you more for your money.

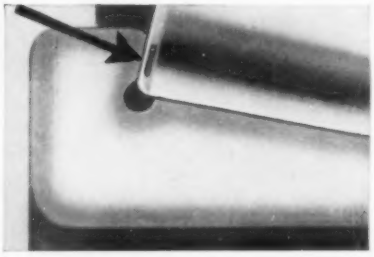


HARD ON THE OUTSIDE, tough on the inside. To take shock loads, give longer life, Timken bearing rollers and races are case-carburized to have a hard, wear-resistant surface over a tough, shock-resistant core.

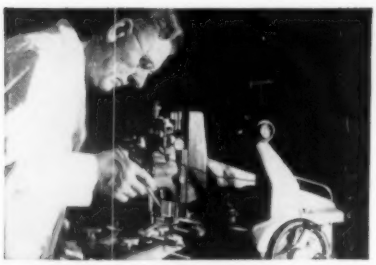


MICRO-INCH FINISH is standard for Timken bearings. This profilograph checks contours and smoothness of circular surfaces to a millionth of an inch, helps us make Timken bearings truer, quieter, longer-wearing.

6,525 SIZES, the world's largest selection of tapered roller bearings. From bearings smaller than your finger to 71½" in inside diameter, the Timken Company can supply the size you need for any specific application.

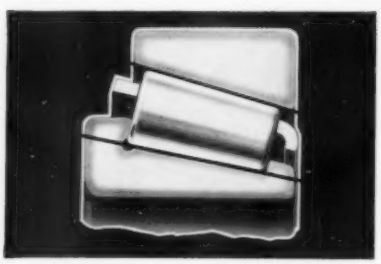


POSITIVE ROLLER ALIGNMENT is assured because the taper in Timken bearings holds ends of rollers snug against the rib. The taper in Timken bearings lets them take radial or thrust loads or any combination.



ACCURATE TO 50 MILLIONTHS of an inch. This Universal Measuring Machine checks gages and machine parts used to make Timken bearings. Our gage laboratory, one of the world's best equipped, helps make Timken tapered roller bearings your No. 1 bearing value.

WE MAKE OUR OWN FINE ALLOY STEEL. No other American bearing maker does. This spectrometer helps control steel quality—in 40 seconds gives the exact chemical analysis of a melt. In a few minutes, results are flashed to the melter. It's another step in rigid quality control.



FULL LINE OF CONTACT between Timken bearings' rollers and races gives them *extra* load-carrying capacity. To get *all* these advantages, specify "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TIMKEN *TAPERED ROLLER BEARINGS ROLL THE LOAD*

TRADE-MARK REG. U. S. PAT. OFF.

ORDNANCE

LAND · SEA · AIR

The Magazine of Scientific and Industrial Preparedness Now in Its 37th Year

VOL. XLI | MAY-JUNE 1957 | NO. 222

The Cover.—*The Nike Hercules is an improved, longer-ranged version of the Army's original Nike surface-to-air guided missile.*

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Gordon Gray . . . . . Frontispiece
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A new method for forming conical and tubular metal parts

TORQMATIC loaders quick shift in all gears

A SIMPLE FLICK OF THE WRIST and your operator can quick shift at full throttle in all three forward and all three reverse speeds.

A shovel loader with TORQMATIC DRIVE can "crowd" a load and get a full scoop every time. The TORQMATIC converter multiplies engine torque more than 300%.

TORQMATIC immediately adjusts to large load variations in loader work cycles without stalling the engine. It allows the engine to run at maximum output during bucket operations, providing maximum power for hydraulic pumps.

Take a tip from 55 manufacturers of 122 different kinds of road-building and construction equipment. Get the Allison TORQMATIC story.

Ask your equipment dealer, or write: Allison Division of General Motors, Box 894W, Indianapolis 6, Ind.

NO. 1 IN A SERIES ON SPEEDING AMERICA'S ROAD-BUILDING PROGRAM

GM TORQMATIC

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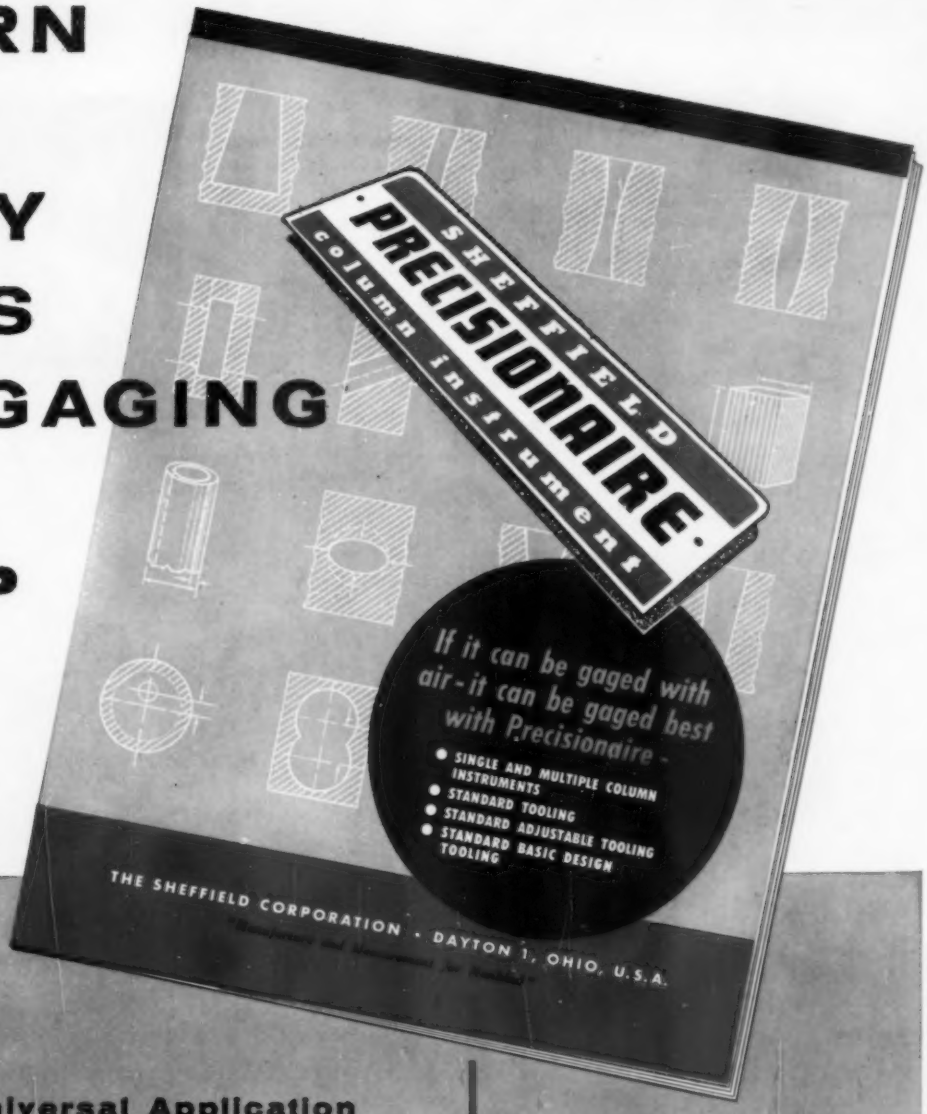
TORQMATIC DRIVES

LEARN THE MANY WAYS AIR GAGING CAN HELP YOU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If it can be gaged with air - it can be gaged best with Precisionaire -
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To the Sheffield Corporation,
Dayton 1, Ohio,
U. S. A. Dept. 14

the **SHEFFIELD** *corporation*

measurement for mankind

7718

923

ARMY PACKAGE POWER REACTOR will go into operation at Fort Belvoir, Va. this Spring.

"HONEST JOHN" JATO is produced by ALCO in quantity.

WEAPONS FROM ALCO LEAD IN DEFENSE

M48A2 tank, in volume production, is one result of ALCO's extensive experience in defense items

Since the Civil War, in every period of danger to the U. S., ALCO has produced defense items and components quickly and efficiently. That experience is apparent today in modern weapons like the M48A2 tank and the "Honest John" artillery rocket. And ALCO-built components are going into leading weapons of the Air Force and Navy, too. Both the "Terrier" and the "Snark" incorporate ALCO items.

ALCO offers leadership in technology. The Army Package Power Reactor, though not a weapon, illustrates ALCO's success in atomics. Built by ALCO under an AEC contract, the APPR will operate at Fort Belvoir this Spring. ALCO has served as design agency for weapons like the M47 tank, too.

ALCO has complete facilities. Seven plants in five states produce weldments, diesel engines, pressure vessels, springs, forgings, precision-machined items — almost anything made from steel. All types of assembly, including electronics, are also capably handled.

For further information, including the brochure "What does it take to make a missile?" write Defense Projects, Dept. ON-1, P.O. Box 1065, Schenectady 1, N. Y.

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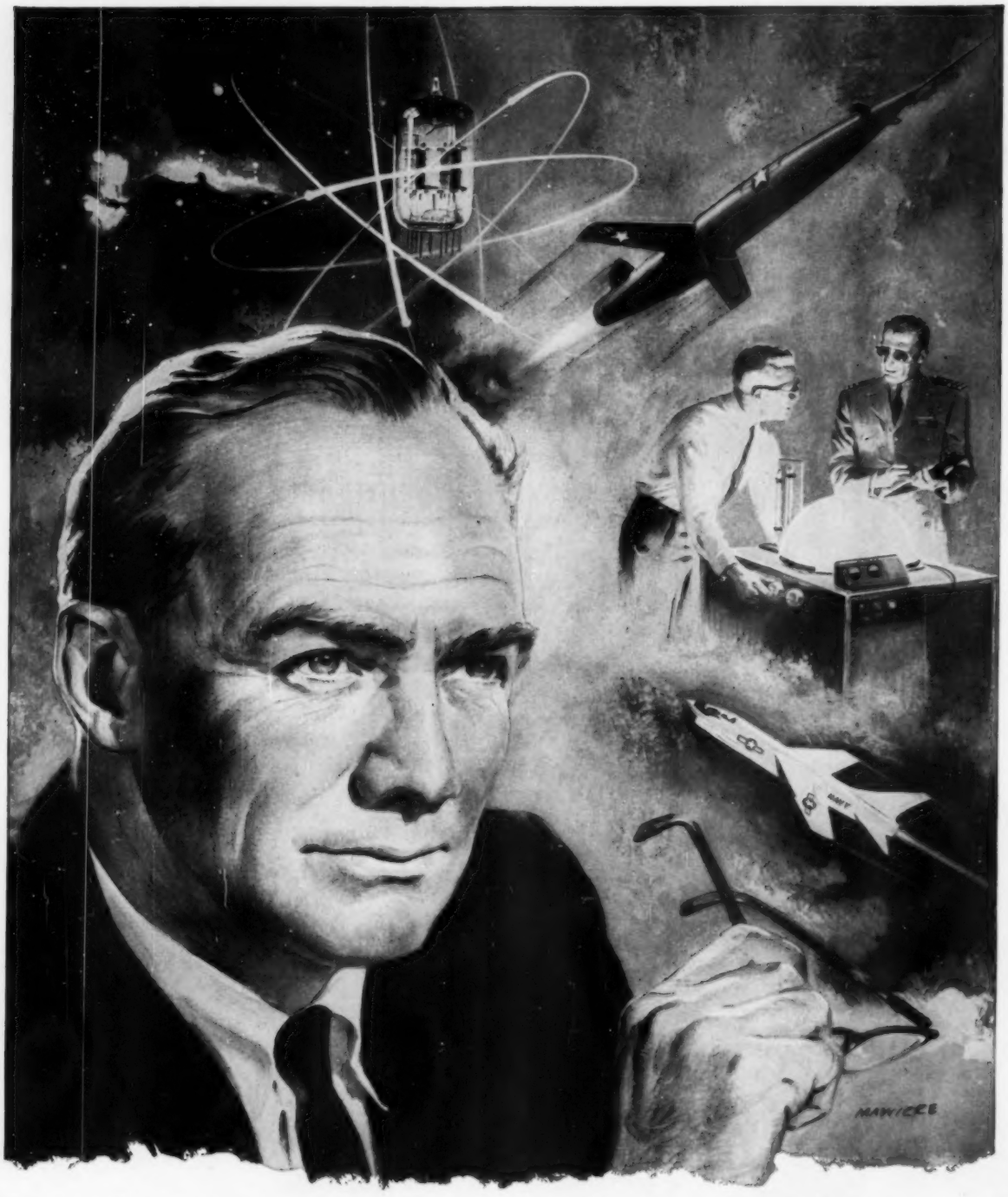
Springs • Steel Pipe • Forgings • Weldments • Oil-Field Equipment

M48A2 TANK is built by ALCO as prime contractor. Since the beginning of World War II, ALCO has produced thousands of tank vehicles.



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He is the man who puts wings on ideas. Through his inventive genius, America is able to maintain peace through preparedness in a complex nuclear age.

He is the man who points the way to tomorrow. His bold approach to the science of flight and to the problems of engineering will bring a better future to all America.

He is the man who has created the remarkable Vought *Regulus* guided missile and the *Crusader* jet fighter. He is the man who is already working on advanced aircraft types that will fly even higher, faster, farther.

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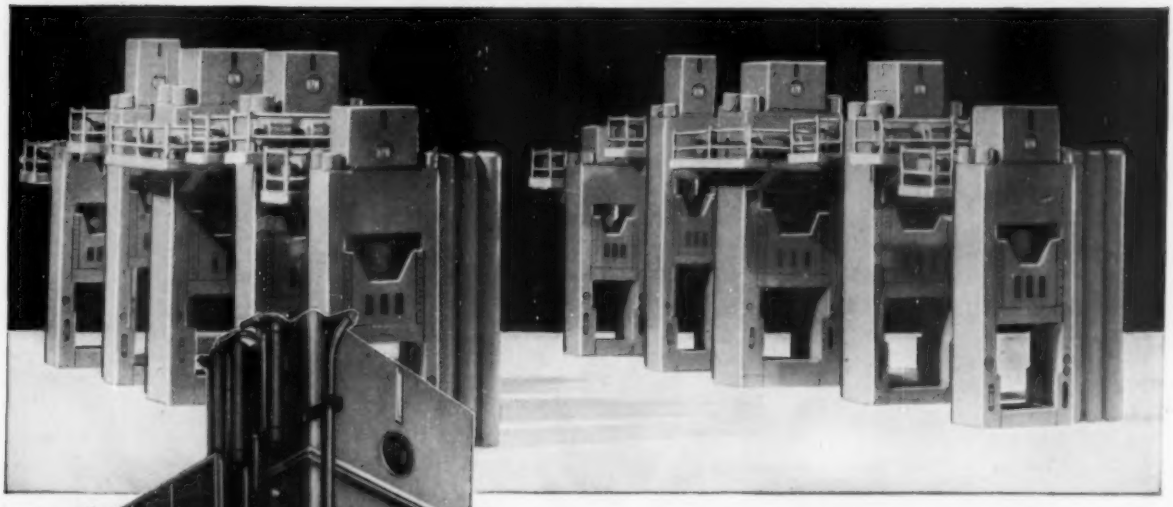

Here's Why More H-P-Ms are Chosen for Shell Production than any other make of Press

H-P-M high explosive shell production know-how has been invaluable through three major emergencies and our preparedness program. Here's the proof ...the above photo shows models of H-P-M presses for two shell lines which will produce 8 inch high explosive shells at a large midwestern plant. And a line of five similar presses has been installed at another plant for the same job. These are the only two major facility contracts placed for shells in the past two years. The presses, tooling and engineering planning are H-P-M standards—standards that the Ordnance Industry team accepts with complete confidence assured through hundreds of successful installations.

Shell manufacture is only one of the important jobs for which H-P-M presses are so widely accepted throughout the metalworking industry. If you have a problem concerned with the forming of metal, complete H-P-M engineering service is available for planning and follow through. For complete information, write or call us today.

The H-P-M 1000-ton press used in hot piercing high explosive 8 inch shells, the first operation in the hot forging, cold extrusion process used in shell manufacture.

HPM

THE HYDRAULIC PRESS MFG. CO.

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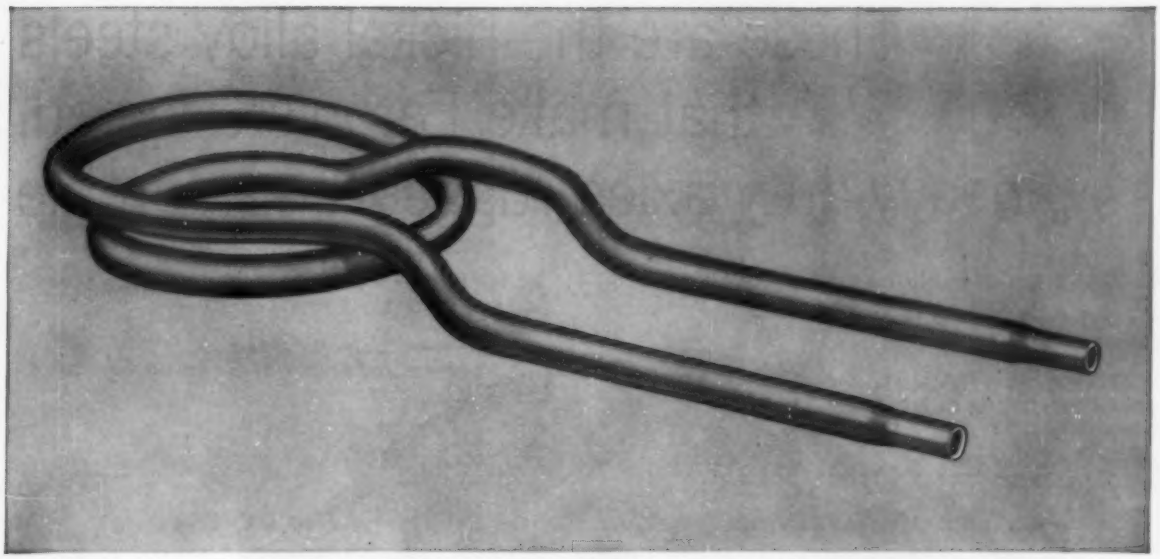
For over 50 years–since the integrated concept of the original navy submarine "Holland"–to the reality of the first nuclear powered submarines, Electric Boat has expanded the "ICT". From simple to complex, "ICT" has now advanced to applications beyond weapons, noise suppression, simulation– to the remote areas of humanistics, thermodynamics and the correlation of concept to concept, complexity to complexity.

Electric Boat's experience in "ICT" can save you months–years in *your* feasibility work with the knowledge of years practically applied. We can adapt the Electric Boat "Integrated Concept Technique" to your feasibility problems.

ELECTRIC BOAT DIVISION

GENERAL DYNAMICS CORPORATION

Write to Dept. ICT10, GROTON, CONNECTICUT



Complex shape of this oil-cooler tube lets it clear moving parts inside a compressor. Swaged ends are ready for brazing.

Bundy helps design a steel pretzel; bends it for Kelvinator compressor

Designing a compressor oil-cooler tube is tricky. It must bend like a pretzel to clear moving parts; stand up to punishing vibration indefinitely . . . yet be mass-produced quickly and economically. So when the problem arose, Kelvinator Division of American Motors Corp. consulted with the tubing experts—Bundy® design engineers.

Working together, Kelvinator and Bundy designers carefully plotted the intricate bends needed for clearance within the compressor. Next, their design took form in Bundyweld® Tubing. Bundyweld is ductile enough for easy fabrication . . . strong enough to withstand vibration fatigue . . . yet costs less than the material used in previous designs. Finally, the job was turned over to Bundy's modern tubing-fabrication facilities for mass production.

This is but one of the countless problems solved by teamwork between Bundy and our customers in many industries. In addition to years of experience, we have the advantage of working with Bundyweld—the only small-diameter tubing made by the exclusive process shown below. *Leak-proof by test*, Bundyweld is the safety standard of the refrigeration and automotive industries . . . *is used on 95% of today's cars, in an average of 20 applications each.*

If you have tubing design or fabrication problems, Bundy has the answers. It will pay you to call, write, or wire us today!

BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN

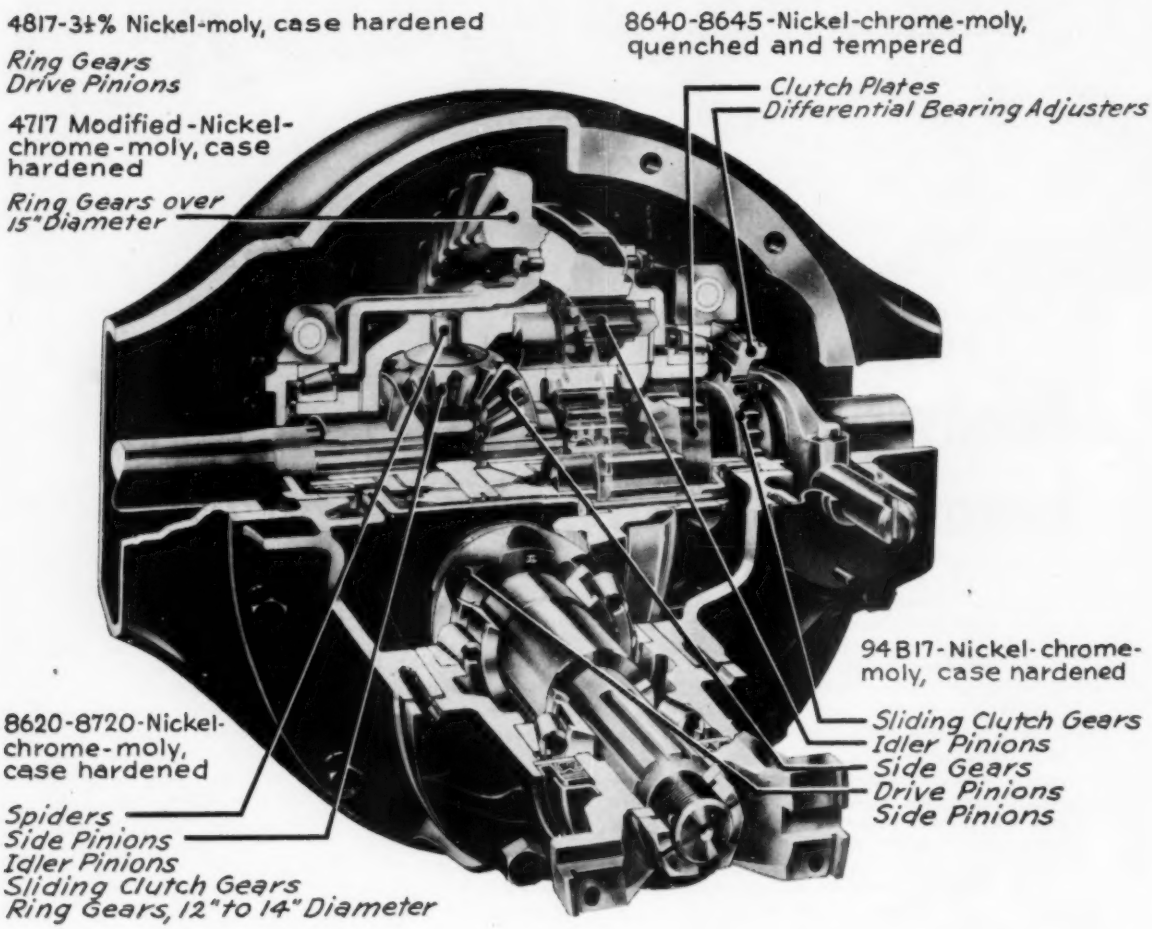
WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY

Bundyweld starts as a single strip of copper-coated steel. Then it's
. . . continuously rolled twice around laterally into a tube of uniform thickness and passed
through a furnace. Copper coating fuses with steel. Result . . .
SIZES UP TO ¾" O.D.
Bundyweld, double-walled and brazed through 360° of wall contact.
NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

BUNDYWELD® TUBING

DOUBLE-WALLED FROM A SINGLE STRIP

These are the nickel alloy steels that make Eaton's 2-speed, heavy-duty axles rugged and durable



Slip this ad under your blotter as a reminder.

It illustrates how a manufacturer — you perhaps — can take advantage of the versatility and true engineering economy of nickel alloy steels.

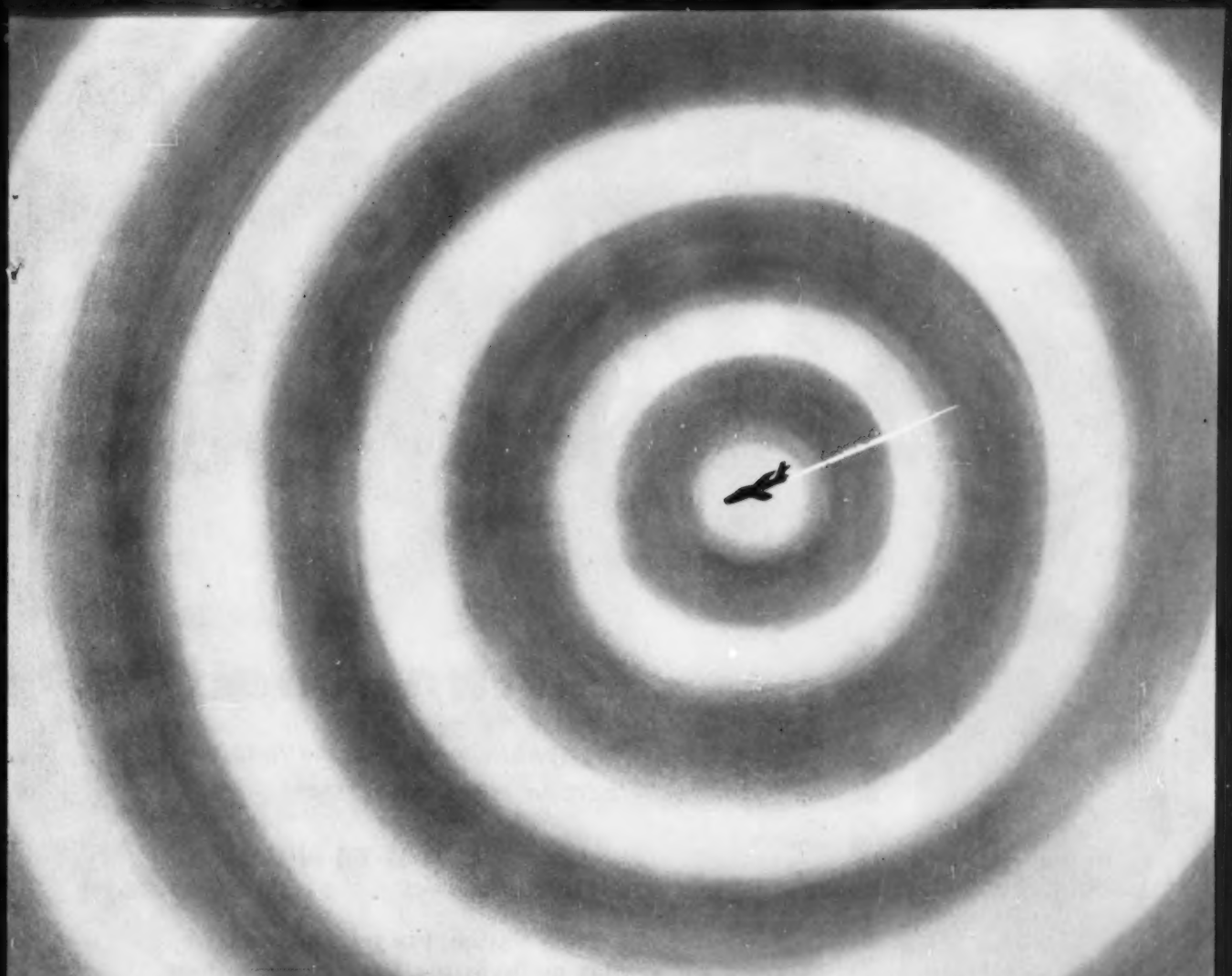
The picture is a view of an Eaton heavy-duty, 2-speed truck axle. It shows the steels Eaton Manufacturing Company of Cleveland, Ohio, uses to make the many axle types rugged and durable . . . hence economical.

Notice how carefully Eaton selected the steels. Each just right for the part.

Leading manufacturers and users of *super-heavy-duty* vehicles know that it does not pay to skimp on materials in parts such as rear axle drive pinions and ring gears. Use of lower alloyed substitute steels would result in frequent failures and replacements, time lost in the shop, more parts sent to the scrap pile, and more steel and alloys eventually consumed. True economy and efficiency means specifying the most durable and dependable materials for vital truck parts.

Moral of the story: what nickel alloy steels do for Eaton, they can do for you. The address below is another reminder: Inco will provide all possible assistance in selecting the most suitable steels for *your* service.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.



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A vital product need just ahead on the horizon, lies in the field of INFRARED*. For detection of any potential aggressor, Hot stuff* comes through! IR* has numerous significant advantages: target size is not critical...a passive seeker, it never divulges its source or location...will outperform radar of comparable dimensions. IR can't be jammed . . . when detecting, it can't be detected. LMEE...pioneering these advantages...has the research and production facilities to make all this a protective reality today. Its Advanced Electronics Center at Ithaca, New York, has an INFRARED Projects Group staffed by recognized authorities on IR development. INFRARED by LMEE...with its broad applications to Airborne Weapons Control Systems...is another LMEE contribution to new uses of Defense Electronics. For information on IR ...write Section B

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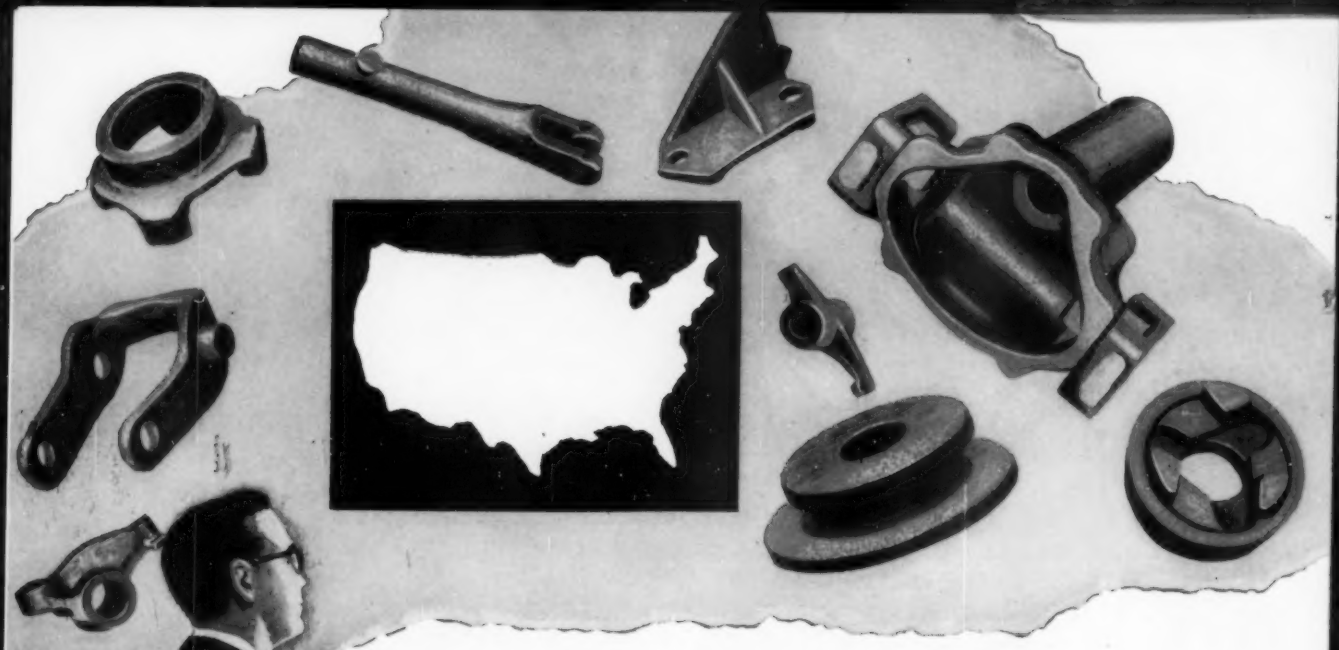

PUZZLED OVER SOURCES

FOR *malleable, pearlitic malleable, carbon steel, alloy steel*

CASTINGS?

Then National is your answer. We play no favorites, have no prejudices —for we cast all these metals.

From our six strategically located foundries, we can supply castings in HTM (Hi-Tensile Malleable), standard malleable, carbon or alloy steel. That means you get all the "multiple source" advantages . . . yet you deal with *one* company having unparalleled facilities in *many* plants. Remember, it's just a *part* of the National story—flexibility of production with individual attention.

AA-4874

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY

Established 1868 • Cleveland 6, Ohio

The nation's largest independent producer of malleable and pearlitic malleable

engineering by BREEZE...

means utmost precision in slip ring assemblies

Engineered and built by an organization long known for its "perfectionist" standards, Breeze slip ring assemblies can be relied on for the utmost in electrical and mechanical qualities.

Each assembly is custom designed and built by specialists, thus permitting individual design and structural features best suited to the application.

We can supply units from 2-ring miniatures to 500 ring giants . . . currents as high as 350 amperes continuous at 220 volts and 700 amperes overload at 220 volts. Special designs for very high voltages . . . radio frequency assemblies . . . high speed rotation for strain gauge and thermocouple applications.

If you have an electro-mechanical problem that slip rings can solve, consult our engineers.

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BREEZE

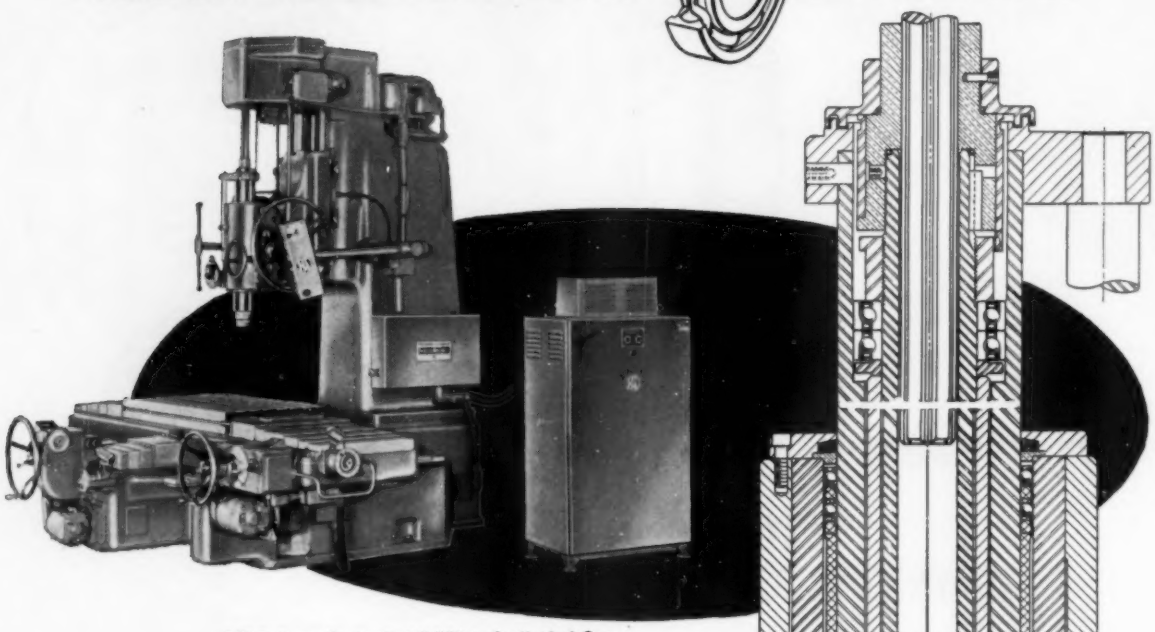
CORPORATIONS, INC.

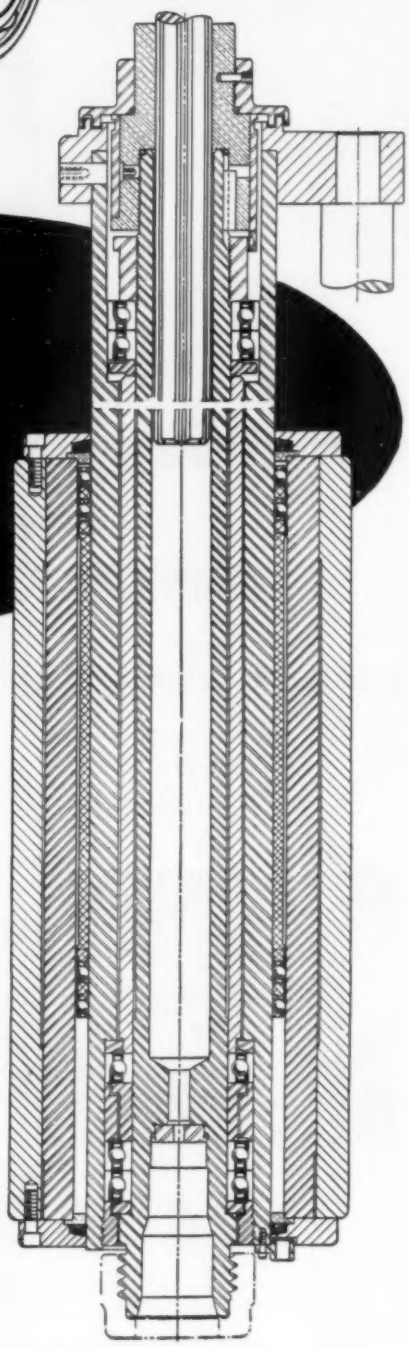
700 Liberty Avenue, Union, N. J.

FACTS

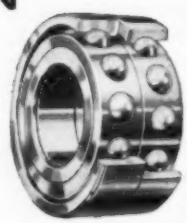
about

NEW DEPARTURE BALL BEARINGS





INVESTMENT IN PRECISION



New Departure Duplex ball bearings are available in a complete range of sizes and series and are made to the finest precision tolerances.

No finely built machine entrusted with cutting metal to extremely small tolerances can be any more precise than the bearings on which its major rotating parts depend.

That's why you'll find this exquisitely accurate Jig Borer Spindle is mounted on New Departure preloaded duplex *ball* bearings. These bearings assure *permanent precision* through a wide range of speeds and feeds.

As a further accuracy feature, the hardened, ground and lapped spindle quill moves on a large number of preloaded steel balls, thereby eliminating any clearances, however small, that would otherwise be required. For more details on New Departure preloaded duplex ball bearings, send for Catalog S.

SEE "WIDE WIDE WORLD" SUNDAYS—NBC-TV

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

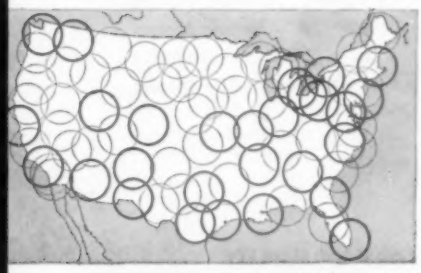
NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

934

ORDNANCE

C.A.A. buys 23 new Raytheon "Flight-Tracker" Radars

Long-range equipment to speed schedules, reduce "stacking" and air lane congestion; assure positive air traffic controls—create "more sky to fly in"



Raytheon radar at 23 of the 28 heavily circled areas will be an integral part of C.A.A. control network. Light circles indicate future coverage.

The Civil Aeronautics Administration has just taken a giant step to solve aviation's biggest problem: air traffic control.

New Raytheon radars with huge 40-foot antennas will be a key part of a complex nationwide air surveillance system that follows and helps safeguard all aircraft during every stage of flight. Radar scopes that display air lane maps pinpoint plane positions at distances up to 200 miles, altitudes to 70,000 feet.

These "Flight-Tracker" radars detect and track aircraft in all kinds of weather—even see through storms. A unique indicator tells the operator when the unit needs servicing.

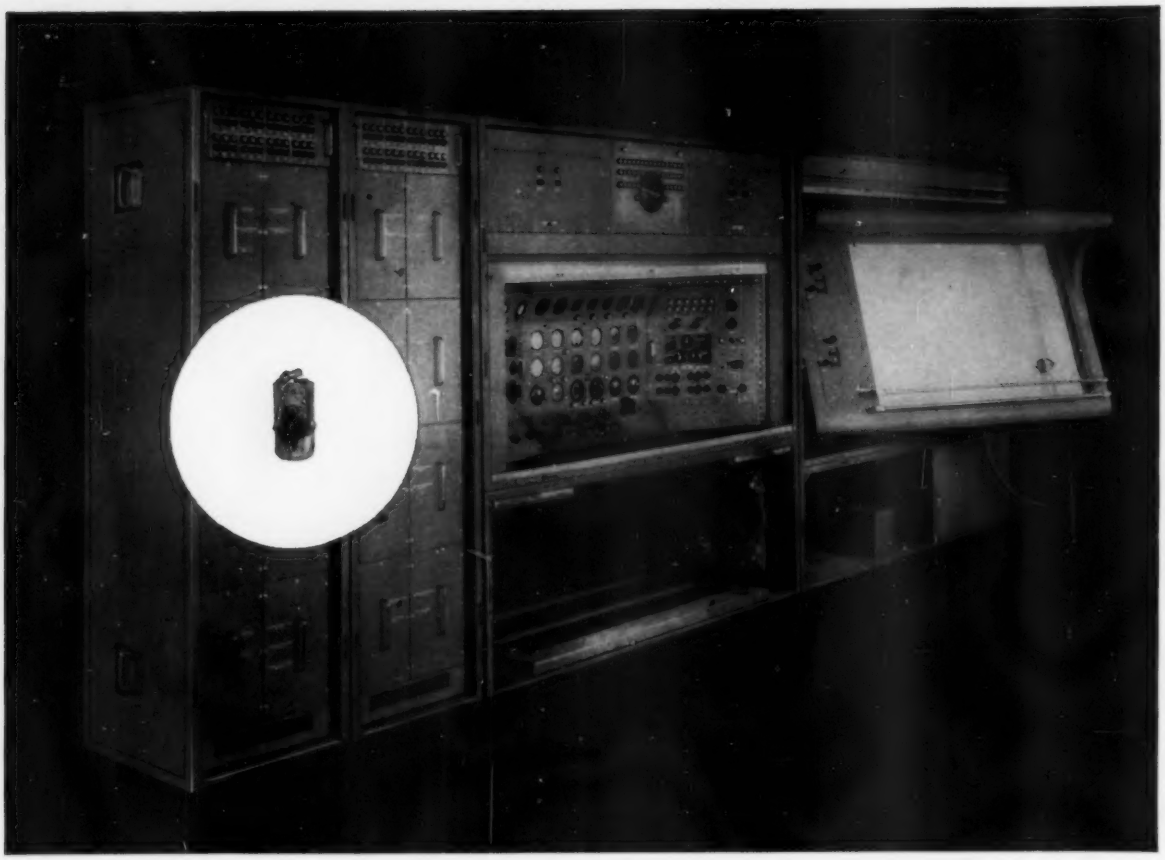
By making possible precise new air traffic patterns, by speeding arrivals and departures, Raytheon radar readies the air lanes for the Jet Age. Here is another instance where Raytheon's "Excellence in Electronics" clears a roadblock from America's path to air progress.

RAYTHEON MANUFACTURING COMPANY

Waltham 54, Massachusetts

RAYTHEON

Excellence in Electronics



From miniature components to integrated systems

AMF has electronics experience you can use

• AMF experience in electronics covers practically every area of the field, from design through production, of individual components and complete systems, for both government and industry.
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• Particular AMF electronics capabilities and products include . . .

Data Processing and Display • Training Devices and Simulators • Antennas and Mounts
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Research, Development, Production in these fields:
- *Armament*
- *Ballistics*
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Defense Products Group
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From Great Lakes Steel come two durable, high-strength steels that let you design longer life, strength with lightness, and economy into your products. With their many diversified applications in modern metal design, it will pay you to investigate the outstanding advantages of these low-alloy, high-strength steels:

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For A-N-Ything in Alnico Magnets

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Materials

Cast Alnico Magnets are most commonly made in Alnico V, VI or III. Sintered Alnico Magnets usually are made in Alnico II, V or VI. Special permanent magnet materials include Vicalloy, Cunico, and Cunife.

Engineering Data

Write for your copy
BULLETIN GC-106 B

Contains useful data on Alnico Magnets, their physical and magnetic properties. Also lists stock items and standard tolerances for cast and sintered magnets.

ADDRESS DEPT. 0-75

Your best bet when looking for a source of Alnico magnets and assemblies is Arnold—producer of the most complete line of magnetic materials in the industry. Arnold can supply your need for any size or shape of Alnico magnet, as illustrated by the variety pictured above. Weights range from a few ounces to 75 pounds or more. Die-cast or sand-cast aluminum jackets, Celastic covers, etc., can be supplied as required. Complete assemblies are available with Permendur, steel or aluminum bases, inserts and keepers as specified —magnetized and stabilized according to the requirements of the application.

A wide range of the more popular shapes and sizes of cast and sintered magnets are carried in stock at Arnold. Unsurpassed plant facilities make possible quick delivery of all special orders. ● *Let us handle your magnetron, traveling wave tube and wave guide permanent magnet requirements, or any other magnetic material specification you may have.*

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Main Office & Plant: Marengo, Illinois

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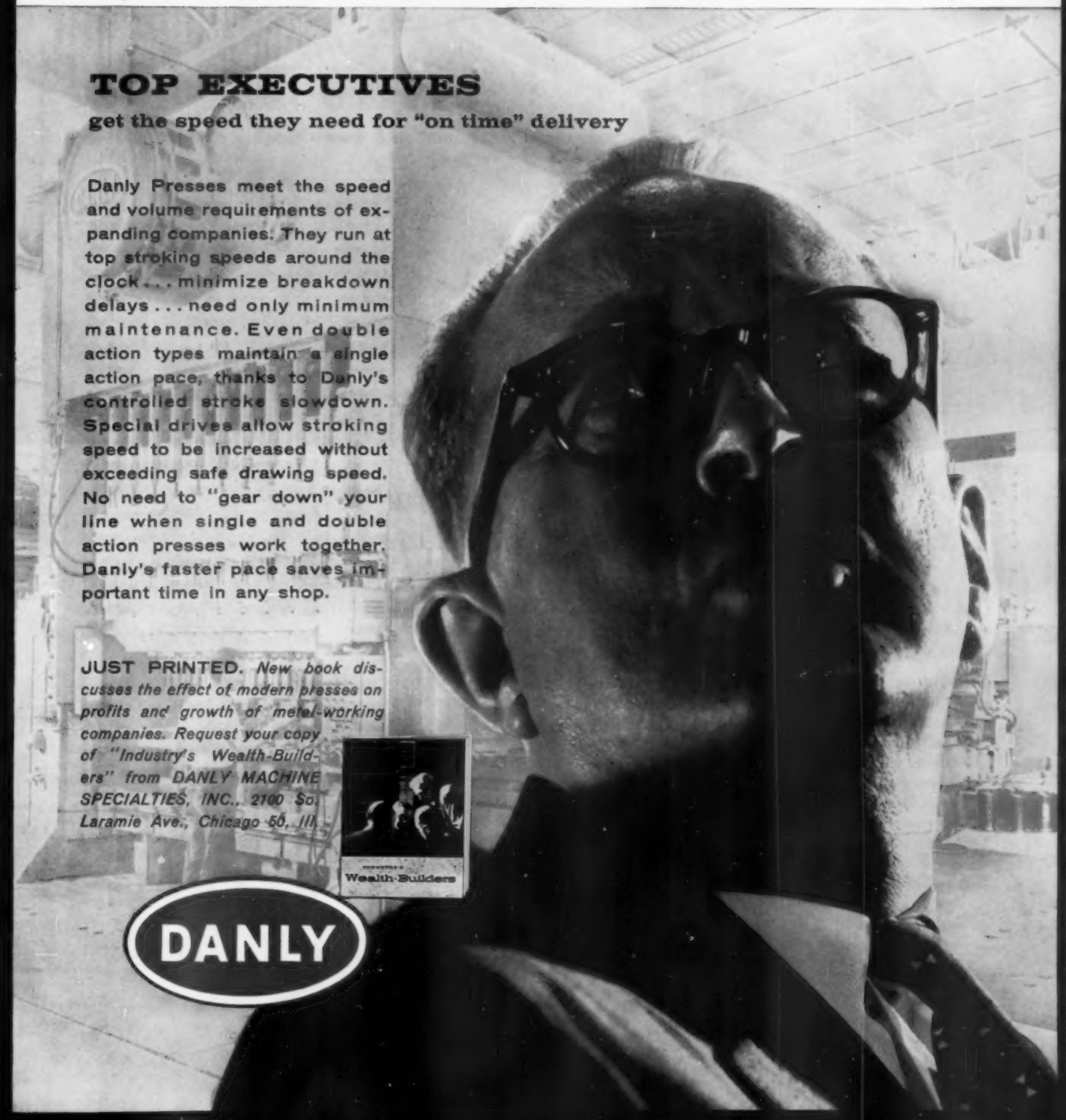


TOP EXECUTIVES

get the speed they need for "on time" delivery

Danly Presses meet the speed and volume requirements of expanding companies. They run at top stroking speeds around the clock . . . minimize breakdown delays . . . need only minimum maintenance. Even double action types maintain a single action pace, thanks to Danly's controlled stroke slowdown. Special drives allow stroking speed to be increased without exceeding safe drawing speed. No need to "gear down" your line when single and double action presses work together. Danly's faster pace saves important time in any shop.

JUST PRINTED. *New book discusses the effect of modern presses on profits and growth of metal-working companies. Request your copy of "Industry's Wealth-Builders" from DANLY MACHINE SPECIALTIES, INC., 2100 So. Laramie Ave., Chicago 50, Ill.*

DANLY

Can you use the talent that built 1,500 Y-4 bombsights on schedule?

These General Mills technicians are representative of the production talent that built more than 1,500 Y-4 bombsights, 1,500 coordinate converters, 1,400 azimuth and sighting angle indicators and 1,400 amplifier and power supply units—and, delivered them to the Air Force *on time*. Here the men inspect a bombsight before it progresses to the next stage of production.

Because we have the highly skilled men—and the men have the specialized tools and machines—we produce precision piece parts or complete, complex assemblies to meet the most exacting requirements.

While building the Y-4 bombsight, we improved original design, exceeded USAF specifications. In addition, our thorough testing facilities assured delivery of only perfect instruments.

Such performance has come to be expected of us and has benefited many other customers. We'd like to help with your production problems too.

Booklet Tells More, explains mechanical and electro-mechanical production facilities. Send to Dept. OD-5, Mechanical Division, General Mills, 1620 Central Ave. N.E., Minneapolis, Minn.

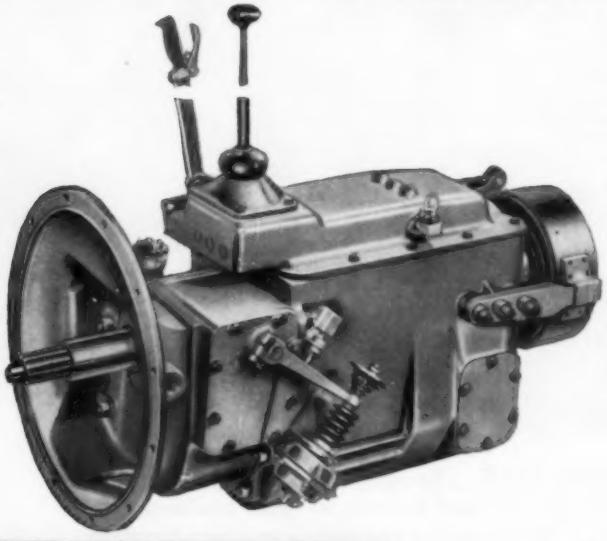
No slow-downs for the B-47— Bombsights ready in advance! During production of the B-47 Stratojet, not a one was kept from the ready-line for lack of a bombsight. The same developmental, engineering and production skills that gave the Air Force on-time delivery are available to speed production of your products.

MECHANICAL DIVISION

CREATIVE RESEARCH AND DEVELOPMENT + PRECISION ENGINEERING AND PRODUCTION

General Mills

Ideal for Highway Hauling-
CLARK stepMatic Transmission



Here's happy and profitable news for all operators whose truck equipment takes punishment—Clark's stepMatic Transmission. This transmission has proved particularly ideal for long-haul, high-speed operations.

- Ten speeds—splitting ratios in between the normal 5-speed transmission ratios—giving 28% steps to fit every hauling need.

Transmission gears synchronized. Semi-automatic shift for the splitting ratios

- Full control of gear-shifting at all times.
- Spares engine—the right ratio for every grade prevents engine lugging—decreases hauling time and fuel consumption.
- Increases transmission life—reduces shock loads. Less downtime for repairs.

By all means write for full information on this highway-proved achievement of Clark engineering.

CLARK® EQUIPMENT

TRANSMISSION DIVISION

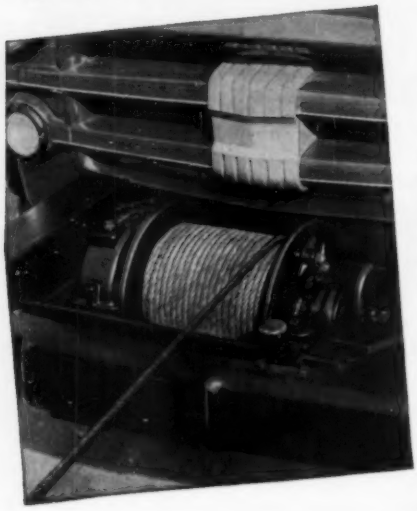
CLARK EQUIPMENT COMPANY

Falahee Road • Jackson 12, Michigan

For ease of operation and maintenance go Gar Wood

In Gar Wood - St. Paul dump bodies, critical stress points are reinforced to eliminate spreading, sagging, or warping. "Strong-Arm" hoist design ties twin lift-arms to a torque tube. Dumping is faster and safer! Servicing is faster too, and can be carried out with ordinary truck tools!

Gar Wood - Buckeye ditchers have advanced hydraulics for maximum ease of operation. Simple, grouped controls mean that all adjustments can be made from the operator's seat . . . without stopping forward travel. Parts interchangeability and "Quick-Change" rooter bits make for faster maintenance. There's a complete line of Gar Wood - Buckeye ladder- and wheel-type models.



Gar Wood winches will never stick or freeze! Clutch is fully enclosed to keep rust, weather and dirt out . . . and it is self-engaging to prevent dangerous slips. Hexagonal shaft permits positive locking of control levers. Worm shaft has self-contained ball thrust bearings that eliminate any need for adjustment!

Gar Wood 75 excavators are easier to operate. Independent travel lets operator hoist or swing while moving. Built-in chain crowd puts full engine power into every bite on shovel applications. Direct manual controls retain true "feel". . . are located for instant control with less effort. Compact design of the machinery deck makes all parts easily accessible!

EVEN THE HARDEST JOB CAN BE MADE EASY... by equipment that is easy to operate and easy to maintain. With Gar Wood, you get advanced features that give maximum ease of operation and maintenance. These are the result of years of engineering and manufacturing experience. Check the complete line of Gar Wood truck equipment and construction machinery. Write to Customer Service Dept., Gar Wood Industries, Inc., Wayne, Michigan.

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The Deadly DART Strikes Home!

The fast and powerful Dart is a rocket propelled surface-to-surface missile designed for Army Ordnance by Aerophysics Development Corporation, a subsidiary of Curtiss-Wright.

The smokeless – solid propellant rocket motor was developed by Grand Central under sub-contracts from Aerophysics Development Corporation and Army Ordnance. The deadly Dart is one more application of dependable solid propellant rocket power by Grand Central.

The Dart is but one of many interesting rocket projects currently under way at Grand Central. We invite qualified applicants to join this congenial and highly-skilled team of scientists.

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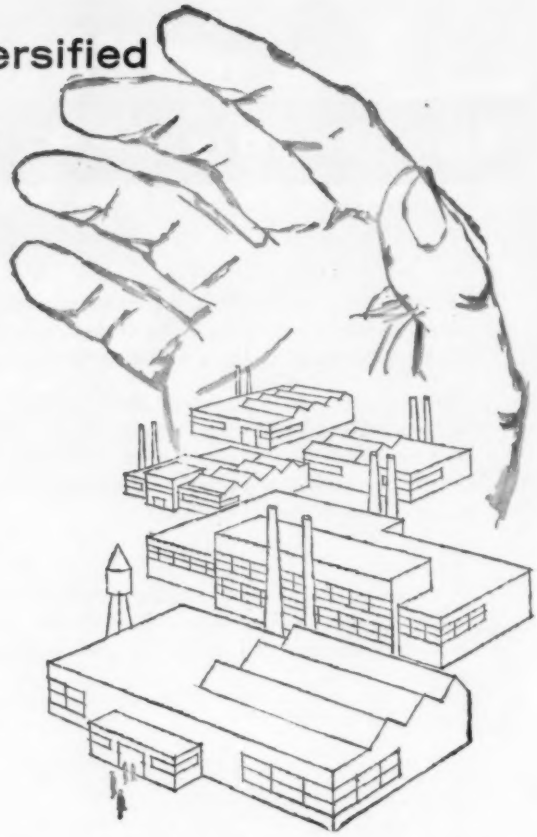
helping hands . . . united yet diversified



Today, it takes more than a better mousetrap for the world to beat a well worn path leading to your door.

Today, it takes the helping hands of diversified industries united under one progressive management.

. . . A management that has the background to cut costs and step-up production, and at the same time insure quality leadership for each and every product.

. . . A management that utilizes the help of each division—in getting the best from all divisions.

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USI is such an organization—a dynamic group of divisions serving many industries where its products are accepted as the finest in the field. An organization that is noted for its ability to give a helping hand to any branch of industry.

CLEARING MACHINE CORPORATION. Mechanical and hydraulic metal-forming presses and accessories. Plants at Chicago, Illinois, and Hamilton, Ohio.

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If you would like specific information on the USI products that are serving with distinction in *your* field, we invite you to write today.

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"A FAMILY OF MEN & MACHINES UNITED TO SERVE INDUSTRY BETTER"

X MINUS 5...4...3...2...1...LAUNCH! HEADED FOR ITS TARGET WITH PINPOINT ACCURACY, THANKS TO AC!

As the fire control officer calls off the seconds before touching the button sending another missile on its way, a new and remarkable device stands ready to take over.

The ACHIEVER—new inertial guidance system built by AC—brings fantastic new accuracy to the ballistic missile field. The "brain" of this wonderful new device is a new-type gyro stabilization of almost unbelievable precision ... so precise, in fact, that thousands of miles of guided flight can be achieved with uncanny accuracy.

The Achiever is a phase of AC's work as a prime contractor on guidance in the Air Force Ballistic Missile Program.

AC

THE ELECTRONICS DIVISION OF GENERAL MOTORS
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Lightweight! But magnesium can really take punishment

Magnesium is the world's lightest structural metal. It weighs only 23% as much as steel, 20% as much as yellow brass and 65% as much as aluminum. But magnesium is strong, too. How strong? Look at a few of its uses in the aircraft industry, for example:

The magnesium wheel in the picture above has to be light, but it also has to withstand tremendous shock when the plane touches down. In another application, the entire weight of a two-ton helicopter is suspended from a magnesium rotor. In large cargo planes magnesium floor members support heavy weights in flight.

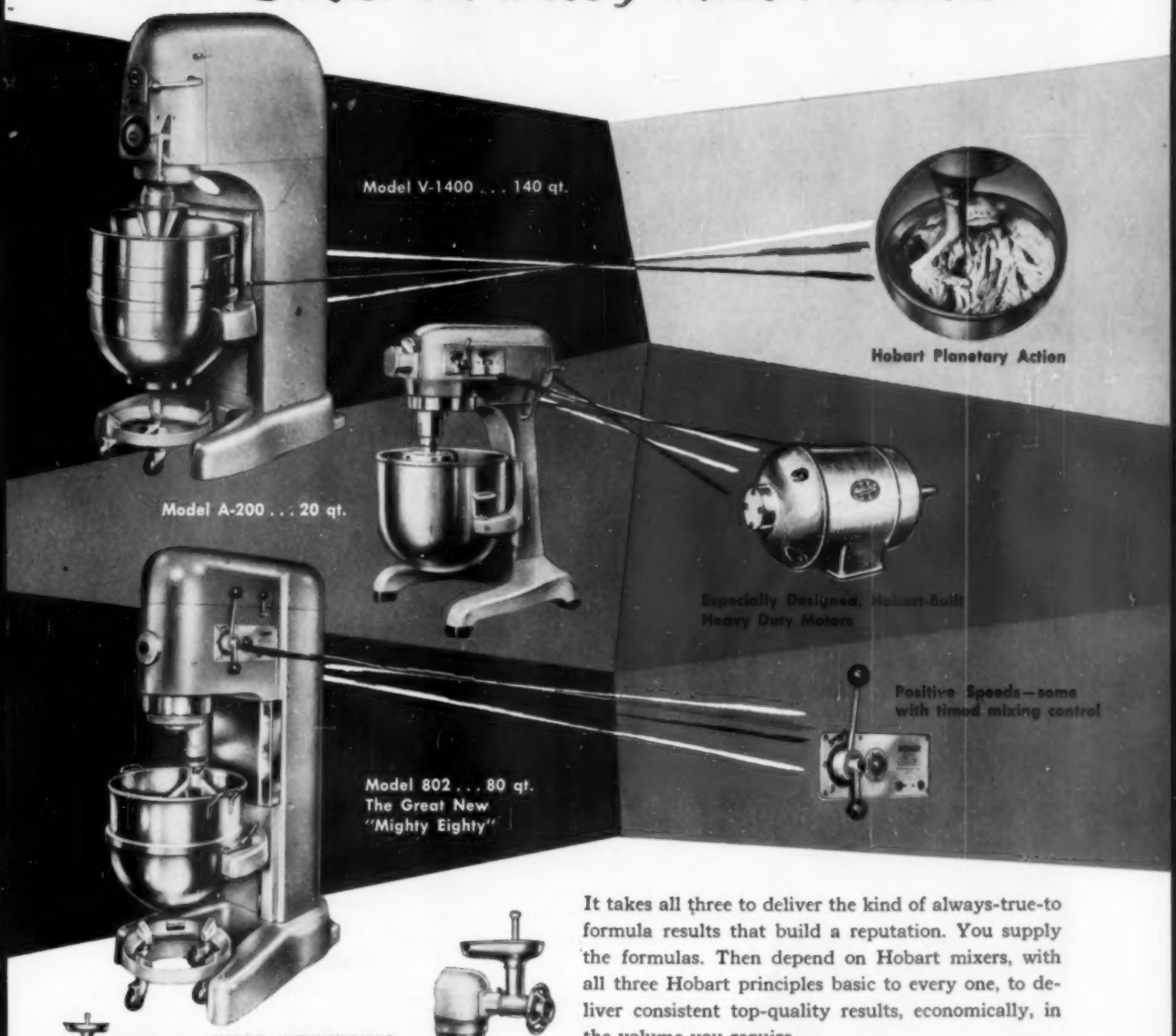
Magnesium was selected because it has the necessary lightness, strength, rigidity, durability and other desirable properties. It's the *combination* of light weight and strength that makes magnesium the choice for countless applications throughout industry.

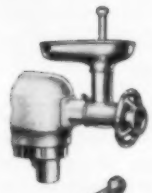
What do these facts mean in terms of your products, parts or equipment? They mean that magnesium can do an equal or better structural job at a substantial savings in weight. For more information, contact the nearest Dow sales office or write to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Department MA 1401N.

YOU CAN DEPEND ON DOW

For Peak Production with Quality Control

Insist on these Mixer Features –


Model V-1400 . . . 140 qt.
Hobart Planetary Action
Model A-200 . . . 20 qt.
Especially Designed, Hobart-Built Heavy Duty Motors
Positive Speeds—some with timed mixing control
Model 802 . . . 80 qt.
The Great New "Mighty Eighty"



ENJOY INTERCHANGEABILITY of Hobart attachments and accessories on other Hobart units, such as the Food Cutter *(left)*. Use them for chopping, slicing, shredding, grating, etc.-in kitchen, bakeshop, pizzeria and salad pantry.

Trademark of Quality Hobart for over 55 years

Hobart machines

The World's Largest Manufacturer of Food, Kitchen and Dishwashing Machines

It takes all three to deliver the kind of always-true-to formula results that build a reputation. You supply the formulas. Then depend on Hobart mixers, with all three Hobart principles basic to every one, to deliver consistent top-quality results, economically, in the volume you require.

And with Hobart, you choose the ideal size or sizes for greatest efficiency for your own operation—choose from 9 models ranging from 5 qt. bench models to the great new Mighty Eighty and 140 qt. heavy-duty floor models. Each gives you easy-to-clean streamlined housings plus the up to date efficiency of using your mixer power plant for added production through the use of a complete assortment of practical attachments. Timed Mixing Control is supplied on many.

Look over the Hobart kitchen machine line today. Make it your first choice for all-round kitchen performance...*The Hobart Manufacturing Co., Troy, Ohio.*

53,000 feet up ...on power by CAE
RYAN Q2 FIREBEE TARGET DRONE
J69-T-9 TURBO JET
J69-T-19A TURBO JET
CAE power chalked up another record recently, when a Ryan XQ-2B Firebee jet target drone set unofficial world's records of 53,000 feet altitude and 104½ minutes of flight at Holloman Air Force Base.
The J69-T-19A is one of three gas turbines now in production at CAE. A second version, the J69-T-9, powers Cessna and Temco jet trainers for Air Force and Navy respectively, while the Model 141 air compressor is the heart of the TC-106 mobile starting unit for jet aircraft.
ENGINEERS!
There's a challenging future at CAE for qualified technicians. For full information, address: C. D. Morris, 1470 Algonquin Avenue, Detroit 15, Michigan.
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ATOMIC ENERGY

ATOMIC PROCESSING

Pending the setting up of commercial services to do the work, the Atomic Energy Commission has established a policy to provide for chemical processing services for the operators of private nuclear reactors.

The Commission offers to contract with the reactor owners providing for the chemical processing and recovery of source and special nuclear material contained in irradiated fuel elements removed from the reactors.

Individually negotiated contracts will establish firm charges for the service, subject to escalation on the basis of an appropriate price index and cancellation by the Commission, after giving twelve months' notice, upon a determination that the services will be commercially available at reasonable prices.

The purpose of the new policy is to give further encouragement to the development of a private atomic-energy industry by giving licensed reactor operators an assured means for recovering the valuable constituents which remain in spent fuel elements after their removal from reactors.

The Commission service covers waste disposal in addition to processing of irradiated fuel elements and blanket materials. It is prepared to contract to provide these services with owners of licensed reactors for a term extending to June 30, 1967. The Commission intends to furnish processing services at similar charges to reactors located abroad fueled with material supplied by the United States.

FIRE-FIGHTING COURSE

A special training course in the nature and control of fires involving materials used in the nuclear-energy industry will be made available by the Atomic Energy Commission to instructors of city and State schools conducted for fire fighters.

The course is offered as part of the Commission's program of coöperation with public health and safety officials of the various states and municipalities in matters associated with the growing private nuclear-energy industry.

The 3-day course will be conducted at schools requesting it. The course is designed for instructors, equipping them to teach others. It will be given without charge, and the instructor-students will

The manufacturers of jet aircraft engines, (and American Welding supplies every major jet engine manufacturer), have learned that there is an inherent savings of material and machining time in the use of flash-welded rings and components fabricated from mill-rolled and extruded shapes.

Might there be a lesson here for the manufacturers of missiles? We think that a missile could go a long way using Amweld's facilities and know-how.

Why not contact our Industrial Products Division today for more information about how Amweld may serve you.

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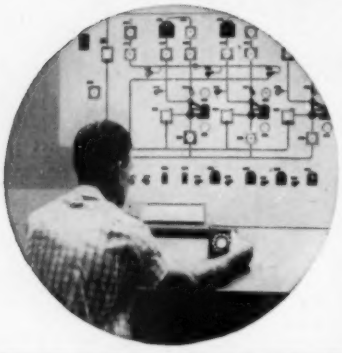
AMERICAN WELDING
The World's Leading Manufacturer of Welded Rings

ENGINEERS

Honeywell's "balanced" diversity brings you more opportunities



This Supervisory DataCenter, which enables one man in one location to control an entire air conditioning system for a large building, is just one of Honeywell's advanced automatic control products for civilian use. Honeywell also develops and produces advanced control devices and systems for the home, farm, industrial processing and factory automation.

Honeywell's Ordnance Division develops and produces such military products as: warheads; infrared systems and components; transistorized converters, inverters and rectifiers; test, checkout and training devices; thermal batteries; electronic fuzing; sonar systems; fire control systems and stabilized platforms.

HONEYWELL, world leader in automatic controls, is following a planned development program which is soundly balanced between civilian and government contracts. This program is giving Honeywell the fastest growth rate in its seventy year history. Earnings have more than doubled in the last five years. The engineering force has increased over 100%.

And Honeywell's exciting growth is continuing. To sustain it, we need skilled DEVELOPMENT, DESIGN, PRODUCTION AND ANALYSIS ENGINEERS to work on the types of products listed above.

You will receive the opportunity to grow with Honeywell, the fastest growing company in America's fastest growing major industry—the Electrical-Electronics industry. You'll work in a small group, your accomplishments will be quickly recognized, rapidly rewarded. You start with a first-rate salary, advance quickly from there. Start today.

Honeywell

First in Controls

MAIL THIS COUPON NOW

Mr. W. D. Conley, Dept. TM 36A
Minneapolis-Honeywell Regulator Company
2753 4th Avenue South, Minneapolis 8, Minnesota

☐ **Résumé attached**
☐ **Send me more information about Honeywell's opportunities**

NAME_____

ADDRESS_____

CITY_____ **ZONE**_____ **STATE**_____

be provided with teaching aids for later use in conducting classes for fire fighters.

RADIATION STANDARDS

The Atomic Energy Commission recently issued a regulation establishing standards for the protection of atomic-energy workers and the public against radiation hazards arising from activities licensed by the Commission.

The regulation was first published in July 1955 as a proposed rule. It has since been submitted for comment to many interested persons and organizations, including State governors and State health and labor commissioners, and the Commission has had the benefit of numerous comments and suggestions. An Advisory Committee of State Officials, appointed by the Commission, has twice met in Washington to consider and comment on the regulation.

Standards are set up in the regulation for the handling of all radioactive materials subject to Commission licensing—special nuclear materials such as uranium 233 and uranium 235, source materials such as natural uranium and thorium, and by-product materials (radioisotopes). Limits are prescribed governing exposure of workers to external radiation, concentrations of radioactive material which may be discharged into air and water, and disposal of radioactive wastes.

Other provisions of the regulation include requirements for surveys of radiation hazards by licensees, monitoring of workers, caution signs, labels, signals, storage of licensed material, and instruction of workers on safe procedures for handling and using licensed materials.

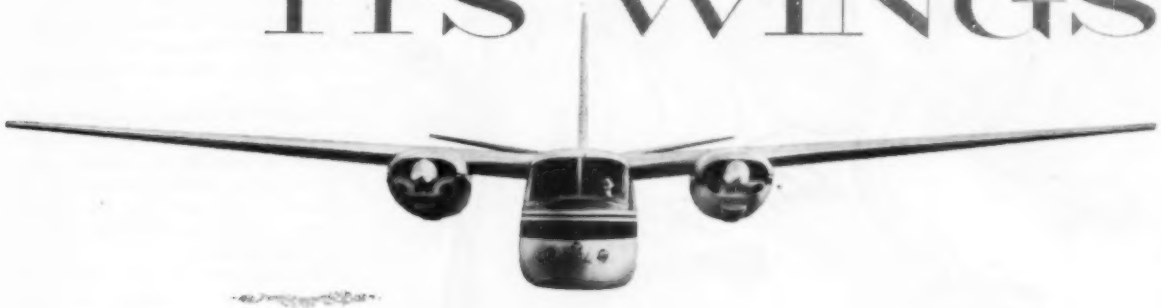
Permissible limits, which except for minor changes are the same as those contained in the earlier proposed regulation, agree substantially with the current recommendations of the National Committee on Radiation Protection in National Bureau of Standards Handbook 52, "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water," and NBS Handbook 59, "Permissible Dose from External Sources of Ionizing Radiation."

The National Committee on Radiation Protection has under review recommendations to limit cumulative exposures over periods of years. The Commission is giving consideration to appropriate amendments to its regulations to deal with this cumulative exposure problem.

It is believed, on the basis of present knowledge, that the standards provide an adequate margin of safety for exposed persons. It is emphasized, however, that the standards are subject to change with the development of new knowledge, with significant increase in the average exposure of the whole population to radiation, and with further experience in administration of the regulatory program.

THE
AERO
COMMANDER

SPREADS ITS WINGS



IN THE NEW 560-E

This newest AERO COMMANDER provides the long range comfort and high speed performance demanded by today's busy, "on-the-go" Executive.

The COMMANDER's soaring, extended wing span teamed with new, powerful Lycoming High Compression Engines stands ready to whisk the flying Executive farther and faster . . . covering the miles coast-to-coast with but one stop.

The versatility of the AERO COMMANDER 560-E makes the necessity of long concrete runways a thing of the past.

As the latest member of the COMMANDER business fleet, this new long-range model incorporates advances in aircraft engineering coupled with the peak performance, beauty, and comfort that has made AERO COMMANDERS the most preferred executive aircraft in the industry today.

To obtain complete information concerning the 560-E or any of the 5 to 7 passenger business fleet AERO COMMANDERS . . . write or wire, AERO DESIGN & ENGINEERING CO, Box 118, Bethany, Oklahoma.

Those who know aircraft best
fly COMMANDERS

AERO Commander

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Call Pioneer now...

Why worry about where to find competent designers and engineers of dies, fixtures, tools and gages.

Pioneer has them for you.

Our highly skilled tool designers and engineers are the permanent solution to engineering overloads in many tool and process engineering departments like your own.

They will be ready to go to work *when and as you need them.* Eliminate worry about temporary overloads and excessive payrolls. Call Pioneer headquarters now.

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INDUSTRIAL ENGINEERS, CONSULTANTS & DESIGNERS
BRANCH OFFICES IN DAYTON, OHIO, WASHINGTON, D. C. and TORONTO, ONT., CAN.

Atomic Energy (Contd.)

The regulation does not cover radiation sources such as X-ray and radium. One of the purposes of the regulation, however, is to assure that exposures to radiation from licensed material, when added to exposures from unlicensed radiation sources possessed by a licensee, such as X-ray and radium, do not exceed the permissible limits.

URANIUM LOANED

The AEC has approved the loan of 5,500 pounds of uranium metal to the U. S. Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio. The uranium will be used in a subcritical assembly for the training of nuclear engineers.

The subcritical assembly consists of an arrangement of uranium rods in a moderator such as graphite or ordinary water. When a neutron source is introduced, nuclear fission is produced, but the reaction cannot be sustained without the presence of the neutron source.

Such assemblies do not require the complex control mechanism, expensive shielding, or heat-removal equipment of nuclear reactors and may be used for many laboratory exercises in nuclear engineering training.

The 5,500 pounds of uranium metal to be loaned the Air Force Institute will be in the form of rods enclosed in aluminum.

MERCHANT SHIP REACTORS

The Atomic Energy Commission and the Maritime Administration recently announced a joint long-range program aimed at developing reactor systems for commercially competitive propulsive power for merchant ships. This program is in addition to the work now progressing on development and construction of the first nuclear-powered merchant ship announced by the President on October 15, 1956.

Under the joint program, the AEC is responsible for funding and directing the development of merchant-ship reactors. In general, the Maritime Administration is responsible for funding and directing the construction of ships, propulsion plants, and nuclear reactors which have passed beyond the development phase.

Under the long-range program the two agencies have contracts with private companies for six design-feasibility studies of four reactor systems.

Additional design-feasibility studies are contemplated. The objective of all the studies is to select the most promising reactor concepts for further development. It is anticipated that work on the reactor systems which are selected as a result of these studies will advance to the component-development phase in 1957 and that reactor experiments may be undertaken later.

Mark of a New and Deadly Guided Missile

"Sidewinder" is the Navy's newest air-to-air guided missile. Flight tests have proved the missile to be as vicious as the desert rattlesnake for which it was named.

In brilliant performances against airborne targets at China Lake, "Sidewinder", Navy's new air-to-air guided missile, has captured the attention of the entire missile industry.

Simple in operation, small and light enough to be carried in quantity by single-seat Interceptors, "Sidewinder" can be fired singly or in salvos. It requires no complex launching system or special pilot training, and it maneuvers deftly at supersonic speeds. The missile displays extremely high single-shot accuracy —and even more important, *it can be launched well beyond reach of the target aircraft's defense.*

"Sidewinder" was developed by the Naval Ordnance Test Station of the Navy Bureau of Ordnance at China Lake, California. Philco assisted NOTS in the research and development program, and performed the subsequent engineering required for manufacture of the missile. "Sidewinder" is *now in full production at the Philco Government and Industrial Division.*

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GORDON GRAY

Director, Office of Defense Mobilization

Defense Mobilization Plans

A Crucial Responsibility of Government and the National Economy

THE Office of Defense Mobilization, formerly headed by Arthur S. Flemming and now directed by Gordon Gray, is the one executive agency established to direct our national mobilization effort, including current defense activities and readiness for any future national emergency. It is the policy-planning and coördinating agency in these important fields.

The Director is a member of the National Security Council and, by invitation of the President, assists the Cabinet in the coördination of the defense mobilization effort with the programs of the Executive Branch of the Government. The broad scope of the organization and of its policies is the gauge of our defense potential. Government, industry, and all phases of our national economic pattern have important parts to play in this direction.

ODM is a small organization. The Director is appointed by the President by and with the advice and consent of the Senate. The operating activities are to the fullest extent possible distributed among existing Government departments and agencies. The work of ODM is carried out under six assistant directors—for Production, Materials, Stabilization, Plans and Readiness, Manpower, and Telecommunications.

THE Office of Defense Mobilization is a logical outgrowth of long experience, much of which was based on trial and error during more than thirty years. The earliest beginnings of defense mobilization studies in time of peace were in the planning branch of the Office of the Assistant Secretary of War. Here were carried forward the provisions of the National Defense Act of 1920 which provided for industrial mobilization planning.

Gordon Gray, recently appointed Director of the Office of Defense of Mobilization, has an outstanding record of public service. Prior to assuming his new duties to which he was appointed by the President on February 27, 1957, he served as Assistant Secretary of Defense for International Security Affairs.

Born in Baltimore, Md., Mr. Gray was graduated from the University of North Carolina in 1930 and Yale Law School in 1933. After practicing law in New York City and Winston-Salem, N. C., in 1937 he became president of the Piedmont Publishing Company, publisher of the *Winston-Salem Journal* and *Twin City Sentinel*, and operator of WSJS and WSJS-TV.

He was elected to the North Carolina State Senate in 1939 from which he resigned in May 1942 to volunteer for Army service. Inducted as a private, he served overseas with headquarters of the Twelfth Army Group. He returned to civilian status in 1945, having attained the rank of captain.

Mr. Gray became Assistant Secretary of the Army in 1947, Under Secretary two years later, and Secretary in 1949. He resigned April 30, 1950, to undertake, as Special Assistant to the President, a study and report upon the foreign economic policy of the United States. Later he became president of the University of North Carolina.

Other governmental assignments included Director of the Psychological Strategy Board, member of the President's Committee on International Information Activities, and chairman of the Personnel Security Board which considered the case of atomic scientist Dr. J. Robert Oppenheimer.

Mr. Gray has received honorary degrees from Wake Forest College, Duke University, Harvard University, and University of California at Los Angeles. He is a life member of the American Ordnance Association.

The pioneering researches of the Planning Branch, directed by officers of the Army, were indelibly marked by Ordnance leadership during many years of study and research. Here the Industrial Mobilization Plan was originally prepared and annually revised. Here the Army Industrial College was started.

From the Planning Branch evolved eventually the present ODM. From the Army Industrial College grew the present impressive Industrial College of the Armed Forces. But the years between were marked by many divisive forces which often detracted from the main objective.

The first of these outgrowths was in time of war when the War Production Board of World War II was established. At war's end came the National Security Resources Board under the provisions of the National Security Act of 1947, and, finally, by a series of Executive Orders in 1953, the Resources Board became the Office of Defense Mobilization.

DEFENSE mobilization has always been of prime interest to the Ordnance Association. Indeed, the beginnings of the A.O.A. and of industrial mobilization planning in the United States are identical. Both came upon the national scene immediately following the First World War, and both were instigated by the same group of loyal citizens who saw the need for official as well as unofficial groups to carry the burden of industrial preparedness.

The Association likewise has grown in strength and, as at the very beginning, continues to uphold the established official agencies in these important fields. To the Director of the Office of Defense Mobilization in 1957 as it did to the Planning Branch, Office of the Assistant Secretary of War, in 1920, the Ordnance Association renews its vigorous and continuing support.

Warfare Tomorrow

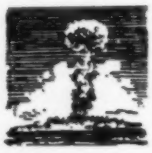
New weapons make the future nature of armed conflict uncertain, but it is possible that a general war might well be conventional while a local war might offer a suitable arena for using low-yield atomic armaments

Lieut. Col. W. C. Magathan

THE multiplicity of weapons systems in the make-up of modern armed forces and the ever-increasing tempo of development infinitely complicate the problem of analyzing the shape of future combat. The proportion of the various weapons systems and the rôles assigned thereto in the military establishment determine in large the general nature of the campaigns which such forces may be called upon to undertake.

The magnitude and characteristics of forces available, relative to those of the prospective foe, dictate the choice of strategic objectives and the quality of the risk involved in any decision to apply armed force.

An objective deemed worthwhile and attainable at one stage of development may appear in a totally different light in a subsequent period of development. Hence there is a requirement for continuing review of policy and strategy and a corresponding stimulus to public debate.



The problem is greatly complicated by the necessity for envisioning probable lines of action of the prospective enemy. Assumptions pertaining to the factors under one's own control may generally be counted upon. Those with respect to the enemy are tenuous at best—particularly when he is granted the initiative.

That the task of prediction was not an easy one even in the days of less complex warfare is clearly evidenced by numerous examples: Jena-Auerstedt 1806, Sedan 1870 and 1949, and the Soviet failures in the defensive battles of 1941.

Colonel Magathan is on the faculty of the Command and General Staff College, Fort Leavenworth, Kans.

Out of the welter of factors involved have come two prevailing views: that conflicts will be general and total or limited. However, the finality of the hydrogen weapon has tended to cast doubt on the utility of general war as a means of securing national objectives.

This dilemma has stimulated investigation of the possibility of "somewhat less than total" conflicts wherein tacit limitations as to means, locales, and objectives apply. Indeed, some form of limited war seems the most likely. Possibilities advanced include complete elimination of thermonuclear weapons, restricting nuclear attack to "purely military targets," and confining atomics to the "battlefield proper."

The weakness of any of the theses which postulate some "shade of gray" is that the limits are not susceptible of clear delineation. Modern weapon effects are so tremendous that coupled with human error and the vagaries of nature the risk is high—over a campaign—that even finite limits, if such could be established, would be overreached.

Considering that the very survival of his force might be at stake, it might be highly imprudent for the "injured party" to withhold retaliation pending a "so sorry, please." To do otherwise would risk development of an irretrievable situation. The "balance of injury" would have to be maintained. Hence the question of limitation is central to the future of the atomic weapon on the battlefield.

PROPONENTS of the theory of limitation rest their claims to feasibility on the success of previous measures to mitigate some of war's more abhorrent aspects which have been codified in the Geneva Conventions. The weakness of the parallel, however, is that the Conventions' provisions nowhere really touch on vital capacities to wage conflict.

Another commonly cited parallel is that of poison gas. Using this analogy, however, in support of the thesis of limited *atomic* conflict, simply does not hold water. World War II was not a *limited* chemical conflict—chemicals were excluded altogether.

Properly drawn, the analogy suggests complete abstention from the use of atomics. This argument, of course, is not new and the "neo-Douhetites" have taken pains to blunt it by arguing that war gas is a rather dull sword at best, and that late in the war, at any rate,

Germany refrained from its use due to air inferiority.

It seems incredible that the effectiveness of this battle-proved weapon should be questioned, considering the ready availability of informed opinion. General Pershing urged the Senate to ratify the 1925 Paris Treaty to outlaw poison gas—otherwise the way would be open "for the use of the most deadly gases and the possible poisoning of whole populations of noncombatant men, women, and children."

BRIG. Gen. Amos A. Fries, Chief of the Chemical Warfare Service, American Expeditionary Force, stated that the use of gas in World War I was child's play compared with what it would be in the future. Liddell Hart wrote: "We are left with the airplane and the tank as the only effective means if gas becomes a standard weapon."

Stalin was so concerned that the Germans might use gas in their 1942 offensive that he secured a pronouncement from Prime Minister Churchill that Great Britain would treat the use of gas on the Soviet Union as if directed against herself and would "retaliate without limit."

A like declaration by President Roosevelt assured the enemy "that the terrible consequences of any use of these inhumane methods on their part will be brought down swiftly and surely upon their own heads."

The point that Germany lacked the requisite control of the air is correct as far as it goes, but it fails to cover the initial phase of the war when the reverse was true. A closer look at this aspect is required.

Germany's decision to use gas in World War I largely depended on conditions existing at the front—on tactical factors. The air arm was in its infancy. Hence strategic air-chemical action could not enter into the calculation to use gas.

However, only the end of the war grounded nascent strategic air forces. A significant dimension was about to be added to warfare, and military thinkers soon married up the chemical and air arms. This attitude was well summed up by Brigadier Lord Thomson, onetime British Air Minister:

"The next war will be fought in the air; it will consist of airplane raids above the great cities . . . Against these, incendiary, explosive, and poison gas bombs will be used."

The German Army's chemical-warfare expert during World War II, Generalleutnant Herman Ochsner, has pointed out that during the interwar period both civilian and military officials in Germany became convinced of the danger to the *whole German nation* of unrestricted chemical warfare and resolved to avoid the use of poison gas unless in reprisal.

How did the situation which confronted Germany at the outset of war in 1939 compare with that in 1915? In 1939 as in 1915 she was on the offensive in a general war. Germany then had to reckon with immediate retaliation—the long-range bomber would involve the entire country in active combat. In addition, Germany simply was not ready to wage offensive gas warfare. The army barely had sufficient gas-defense equipment, not to mention the lack of protection for the civil populace.

Moreover, there were sound tactical reasons influencing Germany to refrain from the use of gas. When it was first employed in 1915 it was regarded as basically an offensive weapon. However, it gradually became apparent that gas actually favored the defense. In fact, the use of chemicals materially sustained the German capacity to carry on the struggle. From the outset of World War II the Oberkommando der Wehrmacht (OKW) was apprehensive lest the Allies themselves introduce gas!

"It would seem equally as incorrect to argue that multilateral possession of nuclear weapons assures their use in future war as to have argued that poison gas would be a feature of the next great conflict. . . . Hence, barring a predilection for hydrogen suicide, the factor of relative disadvantage would militate against an attacker's opening a conflict with nuclear armaments. The defender need resort to them only if his preparations give him no other alternative."

German doctrine held that speed was of the essence, and there were many critical points during the lightning campaigns when the use of gas could have slowed the pace of the spearheads. Of the Eastern Front General Ochsner writes: "We never discovered what caused the Russians consistently to desist from the use of gas . . . [even] in defense of the existence of their state."

America's own chemical expert, Maj. Gen. Alden H. Waitt, soberly points out the danger to the Allied cause implicit in Germany's use of gas as we took the initiative:

"No one can prove it now, but as a student of chemical warfare for nearly thirty years I believe that subjecting our forces to the heavy gas attacks that were possible in Normandy might have delayed our invasion for six months and made later landings at new points necessary."

From a tactical viewpoint alone it is clear that Germany's original decision was sound. Moreover, tactical considerations governed, for Germany at this time was not shackled by an inferior air position as she was later in the war. *Both sides considered that the use of gas tactically would be the signal for its general use.* Hence when the Wehrmacht turned to active consideration of gas, even though its use seemed to hold out good prospects for success *tactically*, the idea had to be abandoned in view of Allied air superiority.

A WEHRMACHT study of the denunciation of international agreements in February 1945 concluded that, "At the present moment the disadvantages of a repudiation of the obligations still kept up to the present in any case by far outweigh the advantages." At his trial in Nürnberg the German Armaments Minister, Albert Speer, testified that when he heard rumors in the fall of 1944 that Goebbels and Ley were considering the use of Germany's new war gases, Tabun and Sarin, in an effort to intensify the war, he stopped their production "since it would not be long before it would bring the most terrible catastrophe upon German cities."

The pattern which emerges is that of those belligerents whose very existence as a nation was at stake—Ger-

many, Russia, France, and Great Britain —none elected to use poison gas. Even prewar opinion to the contrary, and considering the nervousness with which staffs on both sides checked rumors of the use of gas, this abstinence was a truly remarkable but, as we have seen, logical development.

It had been assumed all too readily that a new war automatically would pick up where the last left off. There was little appreciation of the impact on the eventual decision of the defensive qualities of war gas. Moreover, who would have predicted that even nations which had ignored international obligations or avoided such commitments when it suited them would recognize *de facto,* at least, the authority of international law.

Who could have defended an opinion that even dictators who deliberately adopted the most depraved methods as instruments of power would fail to sanction chemical warfare? One is led to believe that even in the face of most disastrous conditions, the body politic apparently intuitively chooses "survival of the species" rather than survival of the nation.

IN our analysis of World War II we have seen air-chemical deterrence operate, not to prevent a war, but, once war got started, to "sanitize" it. The warring powers accepted the principle that if either side took the initiative, the other would retaliate to the maximum degree. Deterrence was proved to be the obverse of retaliation.

However, the degree of deterrence was shown *not* to be necessarily proportional to the effectiveness of the retaliatory threat. Lack of precise information on the *quality* of this threat produced the "safe-side" reaction.

It would seem equally as incorrect to argue that multilateral possession of nuclear weapons assures their use in future war as to have argued that poison gas would be a feature of the next great conflict. Yet a vigorous bomb proponent has this to say of chemical warfare: "Chemical warfare makes life unbearable for the belligerent nations . . . The penalty for a moment's unreadiness night or day, may be death."

This is the reason Air Marshal Saundby adduced for mutual restraint in World War II. Yet would not the sentence have even greater validity if the word "atomic" was substituted for the word "chemical"? It is difficult to see how the Air Marshal can avoid being hoist on his own petard. This is the position in which those who belittle the poison-gas analogy must inescapably find themselves.

> *"Readiness of the United States Army to employ atomics and the maintenance of technological superiority as to weaponry . . . and techniques of integrating the weapon into the battle are of paramount importance.*
>
> *"However, it is absolutely essential that the ghost of moral revulsion against such use be laid to rest and the propaganda that any use of atomics means general war be silenced."*

Just as in the long run the chemical weapon gives an advantage to the defender, so does the atomic. Military history clearly shows that increased firepower tends to favor the defense. Defense rests on firepower and attack on maneuver; the defender can take cover while the attacker must take to the open.

The means to restore maneuver to the ascendency on the atomic battlefield are still lacking. The tank accomplished this purpose in World War II, but severe logistical and technological barriers must be overcome to make the armored vehicle the universal "mobile foxhole" required for a war of maneuver on the atomic battlefield.

HENCE, barring a predilection for hydrogen suicide, this factor of relative disadvantage would militate against an *attacker's* opening a conflict with nuclear armaments. The defender need resort to their use only if his preparations give him no other alternative. However, any use whatsoever might well inaugurate an uncontrollable kilomegaton spiral. Military necessity would be the final arbiter in any case.

Does it not then seem rather more plausible that the "great deterrent" instead of intrinsically precluding war, establishes how war would *not* be conducted?

What then might be the general characteristics of future conflicts?

There is no denying the fact that any war involving the major powers would be fought under the aegis of atomic weapons. Even though armaments were conventional, operations would have to be conducted along the lines visualized for an atomic battle to avoid presenting irresistible temptation or invitation to disaster in the event of an irrational decision.

In view of their expense, missiles would be relatively unattractive implements. Precious strategic air (or missile) forces probably would be husbanded to maintain the "balance of terror" unimpaired.

MOST importantly, the objective of war itself would have to fall short of the modern concept of total defeat to avoid pushing the loser over the nuclear precipice. Both sides would have to be conditioned to accept *limited* defeats or stalemates *à la* Korea. In all likelihood, as Secretary Quarles has said, an atomic power would not accept total defeat while withholding its best weapon. One simply could not bank on a repetition of the rationality demonstrated by Germany in World War II even when *in extremis.*

Nonetheless, the danger would always exist that the objective selected might pose such a threat to the interests of the antagonist that it would lead to broadening of the conflict.

It should be rememberd that the bonds sundered by the armies of the *levée en masse* were the work of a generation which forgot that the conduct of the "chessboard" wars of the eighteenth century had been governed by an abhorrence of the enormities of the Thirty Years' War. Plague, famine, devastation, and degradation on a national scale born of that incredible jumble of conflicts were grim reminders of the penalties of excess.

The elemental magnitude of the Pacific fireball superimposed on the devastation wreaked by nominal weapons on Japanese cities provides the world with a fresh object lesson.

A general or total conflict is fought in two realms, the battlefront proper and the home front. A total war is a national war. It was a consideration of the interaction of the two "fronts" on national capacity to wage the battle which brought about abstention from gas warfare in World War II. World War I in this sense involved the fighting front only.

TO put it another way, strategic factors operative in World War II overrode consideration of a tactically useful weapon. The corollary of this proposition is that where a conflict lacks strategic depth, the scope of weaponry is affected by the prevailing tactical situation alone.

Therefore, wheras a great-power conflict being strategic in nature and involving the entire fiber and structure of nations might well be nonatomic, a "local" conflict fought within relatively circumscribed limits, not involving the immediate issue of national survival and, consequently, rather more "tactical" in nature, might furnish a suitable arena for the employment of atomics, particularly of low-yield weapons susceptible of closer control by the combatant powers and of more readily predictable results.

IN such a case the issue for or against special weapons would be decided on the basis of relative advantage to be gained and the types of targets prescribed. Here, readiness of the United States Army to employ atomics and the maintenance of technological superiority as to weaponry, particularly in the low-yield spectrum, and techniques of integrating the weapon into the battle are of paramount importance.

However, it is absolutely essential that the ghost of moral revulsion against such use be laid to rest and the propaganda that any use of atomics means general war be silenced.

In conclusion it appears that various limitations will characterize future conflicts. The limitations applying in any particular conflict will hinge on the degree to which the major powers are directly involved. In general, however, barring irrationality, the objective of any conflict must fall short of endangering the national existence of either side.

Atomic armaments must be at the ready to police the terms of reference. Within this framework the types of force to be employed will depend on the directness of involvement of the atomic powers and the *relative* advantage to be gained by the application of such force. Conflicts directly involving powers of the first rank probably will not involve the use of atomics in major theaters of operation due to the risk of inaugurating an uncontrollable kilo-megaton spiral.

On the other hand, conflicts of a local or peripheral nature might well provide suitable opportunities for judicious use of atomic weapons, particularly those which are classified in the low-yield spectrum.

THIS is not to say that such are the *only* forms which future wars may take. It does suggest, however, the breadth of the possibility spectrum with which the planner must cope and the consequent flexibility which must accompany planning to avoid the many waiting pitfalls.

"Any war involving the major powers would be fought under the aegis of atomic weapons. . . . The objective would have to fall short of the modern concept of total defeat to avoid pushing the loser over the nuclear precipice."

Small Arms Today

Despite the development of nuclear weapons and guided missiles the foot soldier, with his rifle and machine gun, is still an important part of our defense forces, but science and industry must keep his arms modern

Maj. Gen. J. H. Hinrichs

IF you are inclined to shudder a bit and get dyspepsia contemplating "tomorrow," let me reassure you—tomorrow may not be as bad as you think.

It may, of course, be much better, or, on the other hand, much worse, for any one individual—but from the standpoint of the race as a whole and in the light of centuries and centuries of human experience, tomorrow probably will be only infinitesimally different from today.

Before we get to tomorrow, let us take a short look at today: This is Year Twelve, A.E. (Atomic Era). This is the era that was conceived in the years before August 6, 1945, when it burst upon a largely unsuspecting world with the bloom of the mushroom cloud over Hiroshima. That 20-kiloton baby was the first of a line that is now weighed in megatons.

So today we have available firepower—concentrated firepower—that dwarfs anything previously available in warfare. This has compelled us to study our arms and the organizations, tactics, and strategy that will employ them.

The means of delivery of this concentrated firepower are advancing just as rapidly as the bomb itself. Aircraft today fly great distances at speeds approaching or exceeding the speed of sound. Guided missiles may take the pilot out of the combat airplane. Even some of our artillery today is atomic.

General Hinrichs is Deputy Chief of Ordnance, United States Army, Washington, D.C. This article is based on an address given before a recent meeting of the Small Arms and Small Arms Ammunition Division of the A.O.A. at Eglin Air Force Base, Fla.

Radically new techniques and advances in electronics, and practically all the rest of the physical sciences, are being developed as new or improved means and methods of waging war. And they vastly complicate the business and the art of war, to say nothing of the business and the art of peace!

I think you will agree that today we have a nervous peace. If an enemy interrupts it tomorrow, will we wage a more certain war? Will that war be fought only with "wonder weapons"? I doubt it! It is possible—barely possible—that atomics won't be used. But we must be prepared with them—and to guard against them.

Whether you or I fight on land, sea, or air; in the Army, the Navy, or Air Force; or whether we supply the means to the armed forces—I know you will agree it is of vital concern to each of us that we are prepared with the best possible defense for our Nation.

Now let us look at tomorrow. Our national-defense team is being armed and equipped and organized to deal successfully with any type of aggression—whether the all-out nuclear holocaust, or the so-called "limited" atomic war, or the conventional war, big or little.

Let me narrow the field a bit. The United States Army, the senior member of the Defense team, is proud of the contribution it makes today—and has made ever since 1775—to our national security. But don't get the idea we don't want our sister services in the act—we do!

THE Army in this atomic era is daily becoming more modern, more progressive, more vigorous, more youthful—but we are *not* tossing away the wisdom and experience gained in the 180-odd years of our own service or the lessons of centuries of warfare that preceded us.

Our American soldier today is armed to fight and win in any kind of war that may be forced upon us. His arsenal of available weapons includes everything from his trusty rifle to a mighty ballistic missile with a nuclear warhead. Thus he is prepared to deliver a measured application of force appropriate for any mission or target.

Let me here and now go on record on the importance of small arms in this atomic era.

The aggressor may choose to try the so-called "brush-fire" war—a relatively small aggression in which only conven-

tional weapons would be used. In this case, small arms would become more important than ever.

Even in an atomic war, in which the Army could employ a wide spectrum of nuclear weapons, I can visualize many tactical situations in which an atomic blast would not satisfy the requirement; for example, destroying or capturing an enemy platoon. Bringing down an atomic blast on such a target would be like cracking nuts with a piledriver.

In any case, there would be many occasions around the periphery of an atomic blast, and in other operations like exploiting break-throughs and mopping up, in which small arms would be absolutely vital.

I can visualize no war in which our soldiers will not need a personal weapon for attack or defense. In the widely dispersed units that will be necessitated by the threat of atomics, it will be "mighty lonely out thar without Old Betsy resting in the crook of your arm."

I THINK we can take it for granted that there is not now, and never will be, any so-called "absolute" weapon. Any new weapon changes merely the complexion of war, not its character.

In any kind of war I can visualize no final victory until we control the enemy's land, his resources, his people —and the man who will do this job is the soldier on the ground with his rifle or his other small arms. Therein lies a challenge to the small-arms people in both Ordnance and industry. In these days, weight is of the essence of our problem.

Here, then, in this brief appraisal of our situation, is the measure of the importance of our task in the Small Arms and Small Arms Ammunition Division of the American Ordnance Association. Against this yardstick, let us next appraise the progress we are making in our task.

We have now completed development of the new general-purpose machine gun, the T161E3, which was standardized recently as the M60. It will replace all three of the present caliber .30 machine guns and do the job of all three of them better. It provides equivalent firepower, yet weighs only 23 pounds, as against the 32 to 42 pounds of the machine guns it is intended to replace. (See "The New Machine Gun," by T. E. Cosgrove, on page 1095 of this issue.—EDITOR.)

We have also completed development of the T44 rifle—an accomplishment in which we can all take justifiable pride. The question of adopting a new rifle is, of course, still under consideration. As you know, the rifle is the highest density weapon in the Army. Prior to adoption of any new rifle, the most careful planning and preparation are necessary to assure the earliest, smoothest, most effective, and most economic transition possible.

Priority on delivery of the new general-purpose machine gun will go to the newly reactivated 101st Airborne Division, the famed "Screaming Eagle." The 101st Airborne is the prototype Pentomic division of the new Army. "Pentomic" is a coined word, combining the Greek word for "five" and the tag end of the word "atomic."

Under the Army's new Pentomic concept, our divisions will be made up of five combat groups—each smaller than the regiment, but probably larger than the battalion.

Each combat group will be capable of fully coördinated action, yet independent initiative, to fight and win on the fluid, fast-moving, and wide-ranging battlefield of the future. As we visualize this battlefield, it will range over hundreds of miles in depth and breadth. Combat units will be widely dispersed to avoid the threat of atomic weapons. They will mass rapidly to seize an objective, then disperse again just as rapidly. And, as I said before, Old Betsy, or her future counterpart, will be good company at such times!

Such advanced mobility must be achieved at no expense in striking power. Therefore, all our Ordnance weapons must be lighter, capable of affording more mobility and more air transportability, yet retaining and even increasing their firepower. This is exactly the direction in which we are moving with the new machine gun and all our other small-arms developments.

WITH the emphasis on speed and dispersal and striking power in the Pentomic Army, it is apparent that the substitution of one general-purpose machine gun for the present three separate models will make our combat units much more mobile and effective and yet reduce logistic problems.

A disassembled T44 light caliber .30 rifle resembling a modified version of the standard U. S. M 1 rifle.

It is interesting to note that we now have airborne Ordnancemen who will jump into combat with the airborne divisions of our Pentomic Army. These airborne divisions include an airborne maintenance battalion. While this is a composite unit, including Ordnance, Signal, and Transportation personnel, Ordnancemen make up the bulk of the battalion, and the commander is an Ordnance officer.

Thus, in any future operations there will be small-arms repairmen, as in all past wars, only next time they will be qualified jump soldiers. All Ordnancemen also are trained and ready to fight as infantrymen when the situation so requires.

The new general-purpose machine gun fires the 7.62-mm. NATO cartridge, which many of you helped to develop. We intend soon to begin producing and stockpiling the NATO cartridge in quantity. Incidentally, the U. S. Marines and some of our NATO allies are most enthusiastic about the new machine gun. They may want to use it too.

TURNING now to another recent significant development in small arms, we find an excellent example of our friendly and mutually advantageous working relationship with the Air Force.

This is the Vulcan 20-mm. machine gun, developed by Ordnance for the Air Force with the coöperation of private industry. Vulcan is an adaptation of the principle of the Gatling gun of the nineteenth century. Weighing only about 300 pounds, it provides firepower equivalent to 3 of the 20-mm. guns now in use by the Air Force, which weigh about 175 pounds apiece—another example of decreasing weight yet increasing firepower.

But striking as these recent advances may seem to most, I hold them to be marginal. A few ounces here, a few pounds there, some increases in velocities, some changes in materials. Have we really approached the ultimate in small-arms design or have we leveled off at a point too close to the origin of the curve of progress?

Again, here lies the challenge for the men in industry and Ordnance who concern themselves with small arms. Are we really satisfied with what I have termed the "marginal" progress of recent years? Can we do better?

"There would be many occasions around the periphery of an atomic blast, and in other operations like exploiting break-throughs and mopping up, in which small arms would be absolutely vital."

TO the first question, I, for one, can answer an emphatic "No!" To the second question, I believe the answer is "Yes!" I sincerely hope that all members of the small-arms industry can join me in both answers. The "tomorrow" of the industry depends on it and, more important, maybe the "tomorrow" of the Nation.

How can we do better? If I really knew the answer, there would be little need for the Small Arms and Small Arms Ammunition Division of the A.O.A.! But I can suggest some leads for you that I hope will stimulate your endeavors.

In the first place, let's realize that we are not in a conventional age; that the marginal improvements characteristic of conventionality are not enough; that we must apply ourselves to producing a "quantum jump" in the small-arms art. Next, let us think in terms as bold as trying to produce an "absolute" weapon —a death-ray gun out of the—yes—comic strips!

Is there any reason why handgun makers should be barred from that field? I have a lot of good friends in the powder, shot, and shell business—would I bar them from working in the field of rays to load into the gunmakers' "disintegrator"?

Are there new—really new—metals and processes that would take fifty per cent off the weight of our current light weapons? Are we getting the most out of ceramics and plastics in the light weapons and ammunition field? Have we buried progress under the headstone of conventionality?

These are just a few questions. There must be many, many more that will provoke thought and stimulate answers. Men must ask them. Men must answer them. Men must use the results of your cogitations and the skills of your factories—the arms of tomorrow. Both you and they must be skillful, artful, and persistent. For tomorrow is around the corner!

We are indeed in a most difficult and dangerous situation in this atomic era, but we most certainly do not regard our situation as hopeless or beyond our ability to handle. Rather, we must steadfastly build the defense of America with full confidence that we shall win any war that is forced upon us.

We share with all Americans the task of assuring our national safety and survival. All of us, however, have assumed an additional and very special share of the national-defense responsibility—to provide our fighting men with the finest weapons and ammunition in the world, whether they are to be used on the land, on the sea, or in the air.

We *are* meeting our responsibility; we *are* doing well. We *are* moving in the right direction and making progress. Together, American science and industry and Army Ordnance are getting the job done. But let us not be complacent about it!

I wish I could find words adequate to describe the debt of gratitude we of Army Ordnance feel to all members of the American Ordnance Association. You are the catalyst that makes the Science-Industry-Ordnance Team work. Money could not buy the ability and experience and effort and devotion you give so freely to the national defense.

BUT our task is far from finished. It was difficult even before the dawn of the atomic era. Today it is many times more difficult and more important.

As we successfully accomplish our mission—and we will!—each one of you will share in the supreme satisfaction of knowing that you have helped to place in the hands of the American fighting man the best possible arms to assure that he can fight and survive and win victory whenever he is called on to defend our Nation.

Original drawing by James D. Howze

The Rockets' Red Glare

A centuries-old weapon becomes a valuable addition to the modern arsenal

Maj. Alan R. Toffler

THE rocket, the submarine, the cannon, the machine gun, the tank, and the airplane all can be included on a list of deferred-exploitation items whose military potential was not realized until many years after they were first developed.

This article deals with the reason for the delays encountered in the military exploitation of new development, suggests some ideas which may assist in minimizing the delays, and offers some examples of the military significance of one "new" development—the rocket. I have written with the firm conviction that today's United States Army leaders are fostering an atmosphere in which any new development has a better chance of being rapidly exploited than in any other peacetime period of history.

A summary of factors which has tended to retard the Army's development of new equipment would probably have to be headed by *money*. Peacetime budgetary restrictions will continue to influence research and development efforts. Most military equipment is not applicable to the civilian economy—there is little civilian application for a cannon. Hence research and development pertaining to such equipment must be underwritten by Government funds. However, money is only one factor affecting the development of new weapons.

Certainly a list of such factors would be incomplete if it did not include man's natural reluctance to change. Past records contain many examples of this phenomenon. One such example which could have altered the course of

World War II and of history was the German heavy-water experiments. Hitler, by stopping the efforts of German scientists, may have denied their development of the atomic weapon.

It is well to point out that opposition to change is not limited to the "military mind." The general public has demonstrated a similar attitude in regard to changes in household items, automobiles, men's clothing, or just about anything including the changing of their opinions.

Of course, changes should be approached with mature caution. However, in continually opposing change, we are in danger of becoming our own worst enemy. Without change there can be no progress.

A military arm, a business, or a nation which fails to maintain a receptive attitude toward change in its approach to new concepts and developments can look forward only to its decline.

The evolutionary changes which our Army is presently undergoing serve as positive proof that new developments are not being ignored. Perhaps never before during a period of peace has so much command encouragement been given to the development of fresh ideas. This encouragement includes the development of new tactical concepts, revised organizational structures, and new or improved equipments. The Army is not relying on its past record, no matter how glorious, nor is it depending solely on its present matériel.

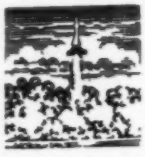
Conversely, the Army is not ignoring its past achievements. What is being sought is a realistic balance between what worked in past wars and what may be required in the next. With optimism and foresight, new concepts and equipment developments are integrated into the Army whenever their potential is demonstrated as tipping the scale in their favor.

BY supporting guided-missile and free rocket development programs the Army is not relinquishing the combat-tested cannon nor is it failing to consider possible improvement in this weapon. However, the Army recognizes that an accurate rocket offers a significant advantage in that a practical version capable of delivering *any* required payload to *any* distance probably can be developed. A cannon capable of doing the same job would be of such size and weight as to render it tactically infeasible.

Major Toffler is Missile and Rocket Research Officer, Department of Tactics and Combined Arms, Artillery and Guided Missile School, Fort Sill, Okla.

The rockets produced in the past were generally of insufficient accuracy to justify their becoming the predominant basic weapon. Even so, they demonstrated their military application and were used extensively by all nations in World War II. The Army's efforts to develop improved rockets during the past decade has begun to pay off. Representative of such weapons, which are in operation in overseas theaters today, are the Honest John free rocket and the Corporal guided missile.

It is well to remember that once these weapons are launched there is no presently known countermissile or technique by which an enemy can destroy them. Other weapons of both shorter and longer range are under continuing development including such rockets and missiles as the Little John, Lacrosse, and Redstone.



In addition to fund shortages and reluctance to change, a third factor which causes the abandonment of some new developments is that early models don't live up to all expectations. It is possible that this factor has been the chief contributor to the seemingly endless delays encountered in new developments. Too readily a concept is abandoned because of some temporary impasse. In other words, when we may be on the verge of a satisfactory solution, we sometimes discard our approach and take off in some other direction.

A corollary of this factor is that any given item of equipment when initially produced may represent a near ultimate within the state of the art as then known. However, we fail to provide funds and resources for continuing modification and development in the light of field experience and new technological achievements. Consequently, the product soon becomes obsolescent and falls into disfavor.

In the case of rockets, this factor and its corollary may explain the searching for another pink cloud which has been going on for over 700 years. The familiar chronological list begins with the first use of rockets in battle generally conceded to the Chinese jet-propelled arrows used in their successful defense of the city of Pien-King in 1232 A.D.

MANY years later Sir William Congreve began rocket experiments which resulted in the use of this weapon by the British, as immortalized in Francis Scott Key's "Star Spangled Banner," written in "the rockets' red glare" at Baltimore in 1812.

The most prominent rocket scientist of the twentieth century was Dr. R. H. Goddard of Clark University, considered the father of modern rocketry because of his first successful firing of a liquid-fueled rocket.

The first military exploitation of Dr. Goddard's invention was the German V-2 rocket of World War II fame. Although this weapon was not too dependable and was practically useless for the attack of pin-point targets, such as a bridge, a railroad, a communications center, or a supply installation, the military potential of the rocket was again proved.

"It seemed likely that, if the German had succeeded in perfecting and using these new weapons (V-1 and V-2) six months earlier than he did, our invasion of Europe would have proved exceedingly difficult, perhaps impossible" (Gen. Dwight D. Eisenhower, "Crusade in Europe," 1948).

The pendulum continues to swing, but recent technological developments are damping its oscillations. For example, the case for those who use inaccuracy as their primary objection to free rockets is being diminished by new developments in propellants, aërodynamics, and warheads. Similarly, the development of rugged electronic gear is weakening the case for those who oppose guided missiles on the grounds of undependability. There appears to be

adequate room in a family of weapons for all types.

CONSEQUENTLY, the Army is continuing the orderly development of free rockets, guided missiles, and cannon. It appears that each can fulfill a definite military requirement. Both the cannon and the free rocket have an advantage over those guided-missile systems which depend on a ground station for guidance commands. Such systems are vulnerable to detection by their electromagnetic radiations and may also be subject to a jamming which can reduce the weapon's accuracy and effectiveness.

The free rocket is relatively easy to mass-produce. Also, a number of free rockets of a given warhead payload capacity can be produced for the same cost as one guided missile of similar capacity. The logistic support required for free rockets in terms of spare parts and highly trained maintenance personnel is far less than that for the guided missile.

On the other hand, the guided missile has distinct advantages for targets requiring pin-point accuracy, and a guidance system appears to be essential for the accurate attack of longer-range targets deep in enemy territory. The cannon fulfills its share of responsibility by providing timely fire which is completely responsive to the requirements of the supported commander.

Most military students agree that we must adopt formations on the battlefield which will decrease the enemy's temptation to use atomic weapons. By spreading ourselves out, the size target offered to him in any one area will be small. Of course, this dispersion is only a portion of the answer to the question of how to wage a successful atomic war. It will be of little value to spread out if we cannot continue to accomplish our mission of defeating the enemy land forces.

It is evident, however, that if we can spread out and continue to provide a decisive volume of firepower, we can effectively support the gaining of control over the enemy's land and his people without inviting atomic disaster on our own forces.

THE rocket, because of its range and warhead-carrying capacity, will permit the necessary dispersion required on the atomic battlefield without sacrificing the required decisive volume of fire. Rockets can converge on objectives from dispersed locations. Often one round can provide the required mass. If an enemy should perfect the rocket before we do, he could position it out of range of our weapons and fire at us with relative immunity. Thus, because of the greater warhead-carrying capacity of rockets the enemy would require fewer weapons to obtain a given lethality. Last, but far from least, he could disperse his weapons over a greater area, thereby presenting a less lucrative target for our atomic counterfire.

IF cannon were dispersed sufficiently to avoid presenting a lucrative atomic target, the dispersion itself would often prevent the required massing of firepower which has been a key to past accomplishment of the mission.

Recognition of the potential weakness of the cannon on the dispersed battlefield is a major reason for the urgency of our rocket development programs. One rocket by its warhead capacity and range satisfies three principles of war—mass, economy of force, and surprise. In addition, the rocket and its ancillary equipment, including its firing platform, is less cumbersome, lighter in weight, and more mobile than a cannon capable of accomplishing the same task.

This mobility is of major tactical significance on a future battlefield where reliance must be placed on greatly dis-

An Honest John rocket is loaded onto its mobile launching platform during a field problem in Germany (Army photo).

persed formations. Tube wear-out, an important consideration with the cannon, is nonexistent with the rocket launcher. Lastly, the rocket launcher requires considerably less critical steel than the cannon.

The present period can be described as transitory. "In short, while retaining its strength in being, the Army is seeking the best combinations to fight tomorrow's war with tomorrow's weapons and techniques" (Gen. Maxwell D. Taylor, Chief of Staff of the Army).

The door to progress is open for the development of the most effective weapons and equipment which American technology and inventive genius can provide. The weapons systems we are seeking must be capable of reliable, accurate, timely delivery in spite of adverse weather, poor visibility, or enemy countermeasures.

The goal of our rocket-development programs should be the building of an end product which can take its place on the battlefield and rightfully enjoy the same confidence factors as are now credited to the cannon. The essential ingredient for the building of this good reputation (for a rocket) is dependability. Such rockets can serve as one more deterrent to war.

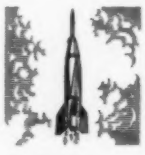
United States industry has accepted this challenge. During the past ten years, branches have been added to existing corporations, and many new firms have been formed. Since 1946 rocket business in the United States has mushroomed into a major industry.

During this same period, each arm and service of the Army has been assuming its responsibilities in developing this "best combination." New training programs have been required, doctrine has required reanalysis, and all arms and services have found it necessary to review their organizations to determine their strengths and weaknesses for carrying out their missions in the light of new developments.

BY and large, it has been agreed that the missions will not change; only the method of accomplishment will change. The basis for this agreement is illustrated by reviewing the mission of a principal user of rockets, the field artillery.

The mission of the field artillery in combat is twofold. First, to support the other arms by fire. This is accomplished by neutralizing or destroying targets which are most dangerous to the supported arms. Accurate rocket fire with warheads of great destructiveness will facilitate the accomplishment of this task. The element of surprise possible by this one-round potential will often permit the neutralization of a target before it can move to cover or before it can close with our ground forces.

The second aspect of the field artillery mission is to give depth to combat and isolate the battlefield. This is accomplished by counterfire, by fire on hostile reserves, by restricting movement in rear areas, and by disrupting hostile command facilities and other installations.



The rôle of the rocket in augmenting and extending the capabilities of cannon-type weapons in the execution of these tasks is practically unlimited. It will permit the force commander through his artillery to continue to concentrate a great volume of firepower wherever it is needed so as to dominate rapidly any threat to the battlefield wherever it may be. Rockets and guided missiles will add power and range to the present effective artillery weapons.

It should be emphasized that military equipment changes need not be of the wholesale or full-scale production variety. During periods of peace, new equipment such as rockets and guided missiles can be programmed over a comparatively long period so that the number of items produced in any month or year will not be great. This permits the incorporation of desirable modifications on later models. Such modifications will always be indicated as a result of new technological achievements or as a result of field testing by a relatively small number of units.

"The weapons systems we are seeking must be capable of reliable, accurate, timely delivery in spite of adverse weather, poor visibility, or enemy countermeasures."

This medium-scale production also has the advantage of permitting the manufacturer to retain experienced personnel on the same job throughout the normal alternating periods of test and change. It ensures that the equipment coming off the production line represents the latest and best possible within the state of the art.

Early models of the equipment can be modified or replaced by the latest models depending on which course is economically most feasible. Medium-scale production may be the best possible means within the budgetary limitations of a democracy for providing the orderly replacement of obsolescent equipment in the hands of troops.

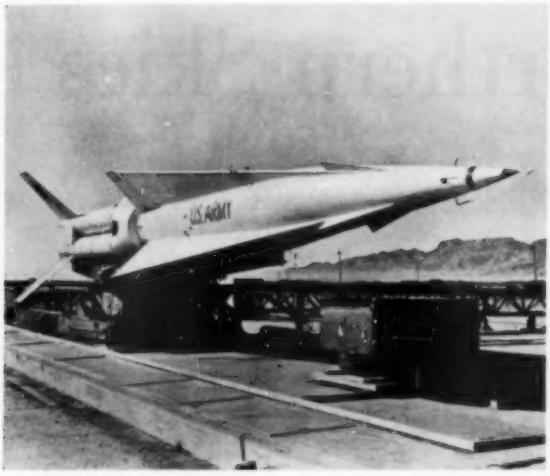
It is evident that an optimistic, positive attitude is reflected by the Army's approach to its task. Any other approach is properly considered contrary to the very foundation on which the Army was formed. The task facing us is tremendous but no more insurmountable than many others we have faced.

IT has often been said that no one is more opposed to war than a soldier, and this basic truth is one additional reason for placing emphasis on rocket development because these weapons can be one more major deterrent to aggression. Further technological achievements will require a continuing analysis of doctrine and concepts to ensure that the best possible triservice team is available to counter any international developments.

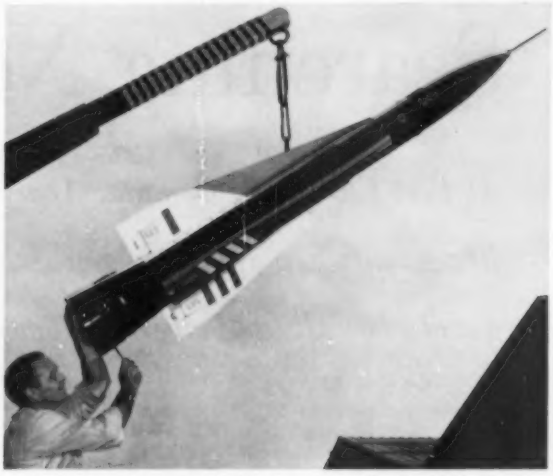
With our sister services and well-trained and well-supplied allies, the United States Army, equipped with the weapons now on hand and which American industry will develop, can maintain deterrent strength on the ground sufficient to hold any enemy in check.

The orderly transition to rockets is as inevitable as the transition from clubs to gunpowder, from horses to trucks. The rate of change is dependent on three factors: money, the ability of the arms and services to assume their traditional responsibilities, and the ability of American technology to turn out end products which can rightfully assume their place in the Army's family of weapons.

In the Missile Arsenal

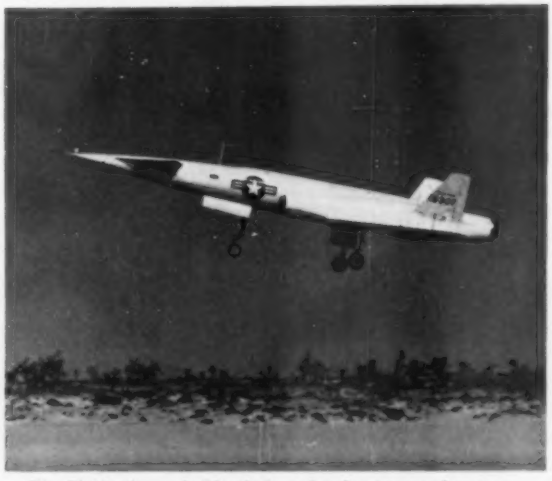


The Nike Hercules, above, is the Army's new, faster, longer-ranged surface-to-air weapon. It will soon replace the original Nike Ajax in guarding our cities.



The experimental missile, above, was developed by the Cornell Aëronautical Laboratory to be fired from high-speed bombers at attacking interceptor aircraft.

The Regulus II, above, is the Navy's new supersonic, long-range guided missile. Lacrosse, below, is the Army's solid-fueled field-artillery guided missile.



The X-10, above, is North American's unmanned test vehicle for the Air Force Navaho intercontinental guided missile. The Army's Dart antitank missile is shown below.

Searching Northern Skies

At Fort Churchill, Canada, Army and Navy experts are planning to fire seventy-five upper-air research rockets to probe the secrets of the aurora borealis and other phenomena in the atmosphere over the Arctic

Warren W. Berning and Lieut. Col. Lloyd G. Smith

FROM July 1957 to January 1959 more than fifty nations will participate and coöperate in the largest peacetime operation in history. Joint international planning on an unprecedented scale has been in progress for the past three years to assure success of this effort. The results of this international program will benefit all mankind and greatly advance the knowledge and understanding of man's environment.

The International Geophysical Year (IGY)—as this period is called—will be a time of concerted study of the earth about us, its atmospheric shell, its life source, the sun, and the particles and radio waves arriving from outside our solar system. The United States research program is divided among the following major disciplines: meteorology, geomagnetism, aurora and airglow, ionospheric physics, solar activity, cosmic rays, longitudes and latitudes, glaciology, oceanography, rockets and satellites, seismology and gravity. The interdependence of the above subjects is obvious, yet each requires investigative procedures peculiar to a particular phase of geophysical research.

THE United States effort in the IGY is under the direction of the National Academy of Sciences operating through a national committee. The program of each of the major disciplines is directed by a technical panel appointed by the National Academy and composed of experts in the various research fields. Support of the National Academy is derived, in turn, from the National Science Foundation.

The above is a very brief survey of the over-all IGY program. We are concerned here with just one phase of the rockets and satellites program. Throughout the IGY the United States plans to launch more than 200 upper-air research rockets from a number of widely scattered locations in the Western and Eastern Hemispheres.

Scientist from the Army, Navy, and Air Force, joined by university research groups, will conduct these firings from Guam to the Arctic Circle to Little America. Most of these rockets will be fired on specific days or during particular intervals which already have been selected as times of intensive study by all nations of a wide variety of geophysical phenomena.

Mr. Berning is chief of the Guidance and Control Branch of the Ballistic Measurements Laboratory, Aberdeen Proving Ground. He is a member of a special committee for the International Geophysical Year and will be the responsible scientist for the launching of five research rockets at Fort Churchill. Colonel Smith is Project Officer at Fort Churchill and leader of the Interservice Support Coördinating Group.

Thanks to the gracious invitation of Canada, approximately seventy-five of these rockets will be launched at Fort Churchill, Manitoba. This launching site, half-way up Hudson Bay, is located just south of the region of greatest auroal displays and provides an ideal spot for studying atmospheric phenomena under conditions of great activity and rapid change. This firing facility was completed in the early fall of last year in time to conduct a series of pre-IGY firings for range testing and calibration.

TWO rather different kinds of rockets were chosen to carry out the research work at Fort Churchill. Each rocket has unique characteristics which make it an ideal vehicle for particular experiments. The first of these, the Nike-Cajun, is a 2-stage solid-propellant rocket employing a slightly modified Nike booster as the first stage and a 6.5-inch Cajun rocket as the second stage. Launched from a modified Nike launcher, this vehicle can carry 100 pounds of payload to 70 miles, or 60 pounds to more than 100 miles' altitude. Having no guidance system, this rocket is exceedingly simple to service and launch—ideal characteristics in the rigorous environment at Fort Churchill.

To carry payloads up to 200 pounds to altitudes as high as 180 miles, several models of the Aërobee sounding rocket will be used. This liquid-fueled rocket is likewise unguided but is booster-

launched from a 100-foot tower. This tower is so gimbaled that it can be tilted in any direction at any angle less than 10 degrees from the vertical. This large tower tilt is necessary to permit safe launching in the rather strong wind environment existing at Fort Churchill.

THE nose-cone instrumentation for these rockets has been designed and will be operated by numerous research groups both within and without the Department of Defense. The Naval Research Laboratory, Air Force Cambridge Research Center, Signal Corps Engineering Laboratories, Ballistic Research Laboratories, University of Michigan, and State University of Iowa will all participate as responsible agents for certain kinds of upper-atmosphere research experiments. A wide variety of atmospheric characteristics and phenomena will be studied and correlated with ground measurements of the other IGY disciplines.

Physical characteristics of the arctic atmosphere such as pressure, temperature, density, winds, and composition will be measured with a number of techniques. The distribution and numbers of electrons and ions in the ionosphere will be studied and measurements taken on the currents flowing in that region during periods of magnetic storms. Studies on the nature of the aurora and the detection of incoming particles responsible for its formation will certainly receive their fair share of rocket flights.

Cosmic and solar radiation are other subjects for intensive study by rocket-borne instruments. In all these experiments, the location of the firing facility at Fort Churchill offers an unparalleled opportunity for probing the atsmosphere frequently and in a region of great activity.

As a result of interservice planning and coördination the Army was assigned the responsibility for establishing and operating the rocket-firing facility at Fort Churchill. This responsibility was further delegated to the Chief of Ordnance. Beginning in the spring of 1956 the Army Engineers completed the almost impossible task of constructing the facility in less than five months.

To accomplish this task the Engineers flew 555 specially selected officers and men to Fort Churchill, and four 96-car trains were used to transport the construction equipment and materials. An average of one aircraft per week was used to transport critical supplies and personnel, and twenty miles of road had to be laid across the swampy tundra.

AN Interservice Support Coördinating Group was formed consisting of representatives of the U. S. Navy, Army Signal Corps, Air Force, and Army Ordnance. Under the supervision of the Ordnance member, this group planned and implemented the interservice logistic and operational support required for the Fort Churchill rocket program. A rocket project was established for the purpose of instrumenting and firing rockets for the IGY program of rocket exploration of the upper atmosphere.

The project consists of three operational groups, each with its own specific mission:

1. An Army Signal detachment pro-

Rocket launching facility at Fort Churchill, Manitoba, under construction in July 1956 (Army photo).

vided by the White Sands Signal Corps Agency, White Sands Proving Ground, N. Mex., consisting of seventy officers, men, and civilians, is responsible for wire and radio communications, meteorological data, radar instrumentation, frequency coördination, range timing, and photographic facilities.

2. A U. S. Navy detachment provided by the Bureau of Ordnance consisting of twenty-five officers, men, and civilians is responsible for the handling and firing of the sounding rockets and furnishing a contract telemetering service.

3. A Ballistic Instrumentation Group provided by the Ordnance Ballistic Research Laboratories, consisting of twenty civilians, is responsible for obtaining ballistic information on rocket flights by use of DOVAP, DOVAP telemetering, and ballistic cameras. The project headquarters, also provided by the BRL, consisting of sixteen officers and men, is responsible for coördinating the activities of the operational groups.

THE Canadian Army has assigned a major as Liaison officer with the project headquarters. The Canadian Defense Research Board has two civilian scientists working with the project, one with the Signal detachment and one with the ballistic instrumentation group.

The U. S. Air Force assists in the support of the project by providing special air transportation for project personnel and equipment.

Post logistical support for the project is being provided by the 7099th First Arctic Test Detachment, U. S. Army. This support is primarily for provision of nontechnical supplies, administration, transportation, and generator operation and maintenance. Generator operation is of tremendous importance since it is the only source of power for the facility. Sixteen 100-kilowatt Diesel generators are in use for this purpose. Other services such as medical, quarters and messing, and minor construction are provided by Canada on a reimbursable basis.

Night firing of an Aërobee is held at Fort Churchill as preliminary testing for the IGY upper-air research program at the launching facility (Army photo).

An important part of any rocket experiment is the knowledge of the rocket's position and velocity throughout the flight. For some experiments this knowledge may be specified in relatively inexact terms, but for others precise knowledge is an essential part of the experiment. As an example, the Signal Corps' experiment for determining atmospheric temperatures and winds requires that measured positions along the trajectory should differ by not more than 10-15 feet from the true position. Again, the experiment of the Ballistic Research Laboratories for determining electron densities in the ionosphere requires trajectory velocities accurate to within one to two feet a second.

To satisfy the needs of the various scientific agencies for knowledge of the positions and velocities of their particular rockets, three range instrumentation systems have been located at Fort Churchill. The most familiar system, radar, has been installed and will be operated by personnel of the Army Signal Corps. This system furnishes trajectory data rapidly and with an accuracy sufficient for many of the rocket experiments. To satisfy the more stringent requirements of accurate trajectory data, the Ballistic Research Laboratories were given the responsibility for installation, operation, and data reduction of the other two range-instrumentation systems. These latter two systems, both of high precision, were developed by the BRL a number of years ago for the White Sands Proving Ground.

THE first of these ranging systems employs high-quality optical devices, called ballistic cameras, which are rigidly fixed in position and whose overlapping fields of view cover the rocket trajectory. In operation, each of these cameras photographs, on a single photographic plate, events or positions along the trajectory together with the star background "seen" by the camera. For daytime firings (of which there will be none at Fort Churchill requiring ballistic cameras) these calibrations are taken the night before and the night after the firing with the plate not disturbed between exposures.

The star calibrations furnish a very

accurate measure of the optical axis pointing direction. Recorded images of rocket events may be related to displacements from the optical axis by suitable measurements and calibration of the photographic plate. Measurements with two such cameras are sufficient to furnish very accurate spacial positions of photographed events by conventional triangulation techniques. At Fort Churchill three cameras will be used to provide more accurate data through overdetermined measurements.

Unfortunately, not all firings are planned for the nighttime nor can one assume that good seeing conditions will obtain at all times. To avoid these limitations, the DOVAP electronic tracking system was installed to provide all-weather, 24-hour precision tracking data. DOVAP (doppler velocity and position) is in concept and operation a relatively simple electronic system and has given excellent service at the White Sands Proving Ground.

Based on an extension of the familiar doppler frequency shift arising from relative motion between a transmitter and a receiver, the DOVAP instrumentation measures the change in the path length of a radio wave from a ground transmitter to the rocket in flight and back to a ground receiver.

Three such transmitter-rocket-receiver path lengths serve to locate the rocket in space through suitable algebraic equations with a high degree of accuracy. Four receiver stations are located on the Fort Churchill range to provide overdetermined and hence more accurate data.

IN order to realize fully the instrumental accuracies of DOVAP and the ballistic camera, it was necessary for the Ballistic Research Laboratories to carry out a high precision geodetic survey. Using the newly developed geodimeter, this survey was accomplished in less than three months. As an example of the precision obtained, instrumentation base lines were measured with an accuracy better than one foot in twenty miles.

During the pre-IGY testing of the Fort Churchill rocket facility, the radar, ballistic camera, and DOVAP operated in a most successful fashion.

"Physical characteristics of the arctic atmosphere such as pressure, temperature, density, winds, and composition will be measured."

The Ordnance Corps' responsibilities in the rocket and guided-missile field lead quite naturally to active interest of the Corps in the upper-air research program in this country. Indeed, problems peculiar to the Ordnance mission dictate participation as well as interest in this research field.

As a part of the upper-air research program within Ordnance, the Ballistic Research Laboratories will instrument twelve Nike-Cajun rockets for firings at White Sands Proving Ground and Fort Churchill during the IGY. A variety of upper-atmosphere phenomena will be studied using these rocket vehicles.

Because communication with high-altitude rockets and guided missiles is of essential importance, considerable emphasis will be placed on a study of ionospheric effects on radio waves as well as characteristics of the ionosphere itself. In one series of experiments the DOVAP system and rocket-borne magnetometers form the basic measuring devices, and it is expected that considerable knowledge will accumulate on the detailed structure and motion of the ionosphere in the auroral regions.

The nature and characteristics of the earth's horizon viewed from high altitudes, and how these are influenced by various cloud structures, are likewise of considerable interest. A series of rockets will be equipped with cameras for photographing the horizon out to distances of 800 miles from Fort Churchill. It is expected that these photographs will reveal the cloud structure and cover over an area of about half a million square miles for firing.

Important to the interpretation of the horizon photographed from high altitudes, and of even greater importance to an understanding of basic atmospheric processes, is the measurement of water vapor at altitudes greater than those obtainable by balloon. To furnish these basic measurements a group of the rockets will be equipped with infrared sensing devices to detect the absorption of solar radiation by atmospheric water vapor.

THE above experiments constitute the principle effort of the Ballistic Research Laboratories in the upper-air research program in the IGY. However, all the rockets carrying DOVAP instrumentation—and these are in the majority at Fort Churchill—will provide data on the density of charged particles in the ionosphere.

Last fall the range and its instrumentation systems were "proved out." One Nike-Cajun and five Aërobee rockets were fired between October 20th and November 23rd with excellent results. Four of the Aërobee rockets were fired in a 9-day period. For one rocket, a total time of only sixty hours elapsed between its receipt at the local railhead and its successful firing. Certain difficulties were encountered in the fall program, and some modifications were found necessary. These latter are presently under way, and the facility will be ready for the full-scale program beginning July 4, 1957.

One of the Ballistic Research Laboratories' systems of three tracking cameras located at Twin Lake Hill, nine miles due south of the Fort Churchill site (Army photo).

Mahan's Logistics Today

Even in modern atomic warfare the great naval strategist's doctrine still applies—reduce the requirement for logistical security to a calculated minimum and build up a striking force capable of destroying any enemy

W. H. Russell

HAS atomic fusion created the absolute vacuum which nature abhors, thereby eliminating all prospect of national security? Or will man's perception of atomics mark another stage in the civilizing technological evolution which began when our forefathers transcended the absolute destructiveness of simple fire?

To resolve this riddle we must examine the impact of atomic technology upon national security. Even in the atomic dawn, the oceans no longer ensure any segment of the United States against surprise devastation by an irrational enemy. Nor can our economy sustain the massive arsenal and trained forces essential for holding every potential aggressor at a truly safe distance.

YET a simple fact makes this condition far less shocking than it seemed at first glance: No other nation is any more secure, nor has any nation the technological depth to support a prolonged atomic war. In terms of atomic technology, ours is again a world of "have-not" nations. Atomic power has not yet been adapted to industry on a large scale. No aircraft in the world boasts an atomic engine. On all the seven seas only one or two operational warcraft are driven by atomic power. Despite the big bomb no nation enjoys an immediate prospect of complete atomic superiority.

Only in a distant future, when atomic technology matures, may we plan again in terms of absolute security. Till that time we must adjust ourselves to the relative security afforded by technological parity. Meanwhile our chances of national survival will be as good as ever if we keep abreast of atomic progress. So for tomorrow the essential military question will be: How to evolve effective logistics amid the atomic revolution in technology?

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This specific problem is new, but civilized man has faced many times its generic ancestor—the necessity of adapting logistical practice to technological change. In the January-February 1954 issue of this magazine Rear Adm. John D. Hayes (U.S.N., Ret.) focused on this question the kind of lucid reasoning which encourages men to take thought. Clearly implicit in his essay is the hypothesis that logistical patterns accommodate to technological change.

Toward the end of every specific evolutionary trend, when technological practice grows relatively static, strong nations enjoy what Hayes called a "logistics of plenty," and they can afford a policy of absolute security. Napoleon climaxed such a period. Clausewitz's study of Napoleonic campaigns still comprises the basic analysis of warfare based upon the logistics of plenty and aimed toward absolute security.

But there is another side to the coin. During the thirteen decades after Waterloo technological change accelerated. The reciprocating engine (driven by steam or liquid fuel), alloy metallurgy, and chemical explosives all developed in an alternating series of dynamic changes interspersed by relatively static periods of technological consolidation.

Each of the three large wars which engulfed this nation in those 130 years coincided with a technological plateau generally similar to that enjoyed by Napoleon. In consequence their patterns illustrated the hypotheses Clausewitz had based upon a logistics of plenty. But during most of our peaceful years between 1815 and 1945 dynamic technology induced an obsolescence so rapid that military men lived constantly amid the dilemma of fighting today's battle with the mere promise of tomorrow's weapon.

IN those periods no nation could maintain a complete arsenal for today while building more expensive weapons for tomorrow. So all nations, perforce, retreated from absolute to relative security. Admiral Hayes characterized such periods of rapid obsolescence as dominated by a "logistics of necessity."

If Clausewitzian concepts of absolute security, massive force, and absolute victory require a logistics of plenty, these same concepts cannot guide us through

the dynamic stage of atomic technology. In this era now dawning, when accelerating obsolescence must impose a logistics of necessity, we should seek guidance from another military analyst whose thinking was conditioned by the kind of circumstances which will surround the next few decades.

Alfred Thayer Mahan fits that description. Born just after the reciprocating engine invaded transport by land and sea, his formative years coincided with those of our metallurgical industry. For sixteen years he lived at West Point while his father, Dennis Hart Mahan, fixed an unobtrusive mark upon Army thought and practice.

After graduating from the U. S. Naval Academy in 1859, the son of that father served through the four years when our Civil War made wood, sail, and simple iron obsolescent as military material—but without providing any substitute.

After 1865 Alfred Mahan came increasingly under the influence of Rear Adm. Stephen B. Luce, D. H. Mahan's counterpart in our nineteenth-century Navy. For thirty years they worked to adapt to seaborne use steel, electricity, and chemical explosives.

Alfred Mahan's personal response to that challenge lies in the eight volumes of military analysis, compiled at Luce's instance, between 1885 and 1911. Mahan drew the bulk of his evidence from the 200 evolutionary years when military seamen gradually shook down the ocean-sailing ship and her iron cannon, but he focused that evidence upon problems conditioned by a logistics of necessity—problems imposed upon the late nineteenth century by a technological revolution similar to our own.

Even though he did not deal specifically with aircraft, the frail vessels of Mahan's day suffered strikingly similar restriction of cruising range and combat endurance.

AS must we, so did Mahan face squarely the hard facts which imposed a logistics of necessity on his times, just as they now impose it upon ours.

This fortunate coincidence of similar circumstances should rouse our interest in what Mahan thought and wrote, even though a full understanding of his work imposes the inconvenience of transposing his nineteenth-century writing into the current idiom.

By way of illustrating this special problem, observe that Mahan rarely used the word "logistics," but instead preferred "communications." Yet so thoroughly did he envisage the precise shadings of "logistics" as we understand it that today's interpreters of Mahan refer increasingly to his concept of "logistical communications."

So thoroughly did his thinking conform to mid-twentieth-century concepts that when he said "communications dominate war" he meant quite literally that what we now call "logistics" dominates war. When the modern reader effects such transpositions as he reads, Mahan's writing assumes truly exciting proportions.

Exactly what did Mahan envision when he wrote of the logistical communications which dominate war? He saw the whole sweep of theory and practice embraced in the concept that logistics involves all aspects of procuring, equipping, organizing, training, transporting, and supplying combat units—a large field indeed.

Early in his commentary on warfare Mahan recognized the fundamental importance of natural resources, industrial capacity, and the other factors generally embraced in our term "producer logistics" which he considered as an essentially civil function, and therefore deserving of small space in his particular work.

Yet this early recognition is important for it comprises the foundation of his detailed examination into the manifold aspects of consumer logistics, which all of us recognize as an essentially military function.

A flash of insight illuminated the field of consumer logistics for Mahan. It showed him an essential distinction between the then conventionl warfare, conducted on terrain featured like that of western Europe, and warfare projected over a vast and almost featureless sea. As Mahan perceived it, this distinction arose from the problem of sustaining secure logistical communications.

For some 500 years before 1885, ground warfare in western Europe had evolved amid terrain features which permitted the well-equipped campaigner to advance from a defensible base of operation by pushing forward a single, rigid, and secure supply column capped at its forward end by an offensive force. In all essentials, this process resembled the building of a pipeline, with occasional advanced pumping stations to sustain an even flow.

However, when Mahan examined very heavily featured mountain regions, or the unfeatured desert and sea, he recognized the impracticability of a rigid and secure line of supply. For in all such regions of the earth the campaigner had to line an artificial supply corridor with combat units, thereby robbing the head of his column of its offensive capacity.

FROM many pages of such evidence Mahan reasoned that whenever combat outran the limits of an ideal terrain, the campaigner had to rely upon relative instead of absolute means for securing his essential logistical flow.

Thus Mahan perceived that every one waging war within a featureless terrain, or under the logistics of necessity, stands between the sharp horns of dilemma because he must keep logistical facilities reasonably secure but without impairing the capacity for offensive combat.

Mahan worked for twenty-five years to convert this dilemma from a hazard to an advantage. As a basic step he reduced the requirement for logistical security to a minimum. Instead of dissipating combat forces to guarantee each logistical installation, he accepted the risk of surprise raids.

Then he assigned to the offensive force, created by assuming this calculated risk, the ultimate mission to seek and destroy any enemy force actually capable of heavy assault upon a nation's essential logistical power.

So in the very broadest sense Mahan envisioned national warfare as a defensive measure intended to secure one's own productive power. Yet within the narrower field of combat he proposed to achieve this defensive object by offensive

action against any military unit in a position to assail the Nation's logistical substructure.

Such reasoning convinced Mahan that a nation can live within the dilemma imposed by logistics of necessity, but only when her armed forces parry one horn of the dilemma till they can blunt the other. He considered damage inflicted by isolated enemy raids as an acceptable price for offensive striking power. He believed that a nation saddled with the logistics of necessity cannot save her life unless she risk it by exposing her logistics to the hazard of enemy raiding.

Mahan reduced this general security policy to an axiom: Never attempt two things at the same time when you lack overwhelming strength; instead hold the enemy in one quarter long enough for your main effort to succeed elsewhere. To apply this axiom, he envisaged a pattern for both logistical and operational disposition which was based on dispersion and mutual support.

Consistently he advocated that individual units of military strength be separated from each other so widely that no single enemy raid might endanger more than one essential component—but that no unit should be separated too widely to sustain its full share of the offensive burden.

IN effect, then, Mahan was a dispersionist willing to accept administrative or logistical inconvenience as the price for attacking the enemy's major military units—offensive strikes which he perceived as the only sound means for securing our own homeland under the logistics of necessity.

For the logistical application of this general security concept Mahan visualized the largest theater for national military operation as a vast circle with its area divided into two regions by a ring of operational bases bordering the national frontiers.

This arbitrary division provided two separate logistical areas—the rear area embracing all logistical facilities within national frontiers, and an advanced area comprising those facilities beyond the frontiers which support specific combat units.

Economy imposed by rapid obsolescence induced Mahan to reject the conventional European concept of monolithic and absolutely secure logistical installations within national frontiers. He held that duplicate transport routes should link producing areas to assembly stations and that at least dual transport lines should link each assembly station to several frontier bases.

Mahan considered the administrative complexity inherent in this pattern as a real economy in that it reduced materially the potential damage from a single enemy raid.

Thus he felt justified in relying on small defensive units for a defense of attrition to discourage raiding rather than on massive forces aimed at destroying all attackers.

Mahan assumed this calculated risk in the rear area in order to mount strong offensive forces beyond the circle of operational frontier bases. In any advanced theater he built his arrangements around a specific offensive force. This force, he said, should have as its objective to seek and destroy whatever enemy force possessed the actual power to disrupt friendly logistical communications.

In an immediate sense the objective was an enemy able to shatter logistics of the friendly offensive force, but Mahan's ultimate objective was the enemy combat unit capable of disrupting significant national logistics.

Should this seek-and-destroy mission send an offensive force so far forward that it required advanced bases, Mahan advocated the same pattern of dispersion and mutual support that he had envisioned in the logistical rear.

This pattern projected at least a dual line of approach to any distant objective—with the two advancing arms so widely separated that no enemy assault could threaten both—and with the several advanced bases comprising each arm too widely separated for a single enemy raid to threaten more than one base. As in the logistical rear, Mahan held that each advanced base should possess enough defensive strength to punish enemy raiders, but not enough to provide absolute security. Whenever a strong enemy force flanking one of the advanced logistical arms threatened to drain the forward combat unit of its offensive power, Mahan insisted that the flanking enemy become an intermediate objective of the forward combat unit.

"Mahan would emphasize fire effect rather than a mere mass of explosive. He would rely on relatively light, highly accurate weapons susceptible of flexible use rather than on a super-hydrogen bomb."

IN projecting his calculated-risk pattern for national security Mahan assumed a capacity to organize and train efficient combat units. If, for instance, an enemy proved overwhelmingly strong or if he refused to join battle, the offensive commander must manuver to draw his enemy away from significant logistical installations and yet bring him to battle in favorable circumstances.

For this delicate mission Mahan advocated the classic bait-trap gambit, either for whittling the enemy to manageable proportions or for destroying him. Economy turned Mahan away from the convenience of massive forces-in-being.

Instead he favored the kind of mobile, articulated force which Stonewall Jackson used so well when he relied on an exposed element to which combat units rallied more rapidly than an enemy thought possible. Mahan visualized this operational concept by asserting that an offensive striking force should never resemble a flock of sheep, all huddled together, but a fan that opens and shuts.

WE have observed clear parallels between Mahan's time and our own. Then, as now, dynamic technology buried in a riddle the problem of national security, the logistics of necessity embraced this riddle in a dilemma, and the inscrutable future wrapped the whole in a mystery.

But we enjoy an advantage over Mahan. His fruitful analyses afford us guidance for penetrating the mystery of our future. One who looks to Mahan

for light upon our future will perceive a need in each of our armed services for many balanced and articulated task units, each capable of delivering effective fire, instead of the need for a few massive units relying on the heaviest weapons available.

Though he is generally called an advocate of the battleship and her heavy ordnance, Mahan differed radically (albeit quietly) with Lieut. Comdr. William S. Sims, U.S.N., when that officer crusaded for the all-big-gun ship. Mahan believed that relatively light, rapid-firing ordnance would prove more significant in future combat than would the slower, heavier guns.

HIS projection in 1911 of a hypothetical amphibious campaign across the Pacific foreshadows clearly the kind of articulated, circular task forces actually developed during the 1940's as well as the dual and flexible supply lines such task forces require. In this same hypothetical transpacific campaign he emphasized the critical need for a force of heavily reënforced infantry advancing with the assault force and capable of seizing enemy bases, either en route to or upon the far shore.

Projected down to our own time, these combat requirements suggest clearly the logistical system Mahan might advocate if he were alive today.

He would approve thoroughly of a strategic air force capable of deterring surprise attack against targets inside the United States. But Mahan would use this force as its name implies; that is, as a strategic reserve wherewith the highest command echelon may intervene at the climactic moment.

Mahan would not, as a fixed rule, propose to use this strategic reserve as a preliminary striking force, or against enemy producer logistics, but would establish as priority targets the bases from which long-range enemy air units might be launched.

Thereby he would not conceive of a plane- or missile-carried superexplosive as anything like an absolute weapon but rather as the climactic component in a weapon system. Mahan also would envisage a fleet of aircraft to support the very-long-ranged bomber. This fleet would include refuelers, air-to-air fighters, and planes capable of suppressing ground-to-air fire or of neutralizing enemy airfields.

"During most of our peaceful years between 1915 and 1945 dynamic technology induced an obsolescence so rapid that military men lived amid the dilemma of fighting today's battle with the mere promise of tomorrow's weapon."

Mahan could assume that such a strategic air reserve might deter similar enemy force, but without inhibiting piecemeal advance by his smaller units. Against that prospect he would advocate air- and seaborne task forces built around large seaplanes and a few large carriers; task forces capable of projecting onto hostile land highly mobile ground units to seize and hold a key position, even when encircled by the enemy.

Missions for such a task force might comprise denying to the enemy a vital base, establishing a dual line of advanced bases to sustain offensive combat, or projecting a ground-air team deep into enemy country. For this last mission Mahan would be far more interested in separate thrusts by dispersed battalion combat teams than in sustained assault by divisions or corps.

In all elements of such a task force Mahan would emphasize fire effect rather than a mere mass of explosive. He would rely on relatively light, highly accurate weapons susceptible of flexible use rather than on a superhydrogen bomb. In terms of power plants he would know from his own experience that the kind of force our security demands can become a safe reality only when atomic energy may be developed to propel aircraft, ships, and ground vehicles.

Until the distant day when atomic technology matures sufficiently to provide in quantity such weapons and power plants, Mahan would advocate a logistics of necessity. In the field of producer logistics he would encourage industry to develop atomic power for profit, but with production centers dispersed far more carefully than was possible when coal was the principal source of power.

In the field of consumer logistics he would accept the administrative inconvenience inherent in wide dispersion and duplicate transport lines. Everywhere he would accept the calculated risk implicit in relative security as the price to be paid for significant o. ensive power.

It may seem strange that we look into the future by studying the work of a man who fought in the Civil War and died in 1914; but learning from men long dead is not without some precedent.

In 1943 during the Solomons operation Comdr. Arleigh Burke bore a strong hand in adapting destroyer tactics to radar and the long-lance torpedo.

Yet today Admiral Burke readily admits that his inspiration for those "new" tactics came from reading how Scipio Africanus had defeated Hannibal some 2,000 years before—a victory won under the logistics of necessity and on a virtually featureless African terrain.

IN this context recall how Admiral Hayes illustrated the logistics of necessity in his ORDNANCE article of three years ago. He used a formula for kinetic energy derived from Newton: $E = MV^2$, or energy developed equals mass times the square of its own velocity. Applying this generalization to logistics, Hayes observed that velocity is the squared factor.

Therefore, he reasoned, the efficient secret of today's military economy lies not in creating a mass of logistical units but rather in the speed of forwarding logistic essentials to the point of consumption. And though he was reasoning from Newton, Admiral Hayes summarized clearly Mahan's conclusions about warfare.

Such parallels are relevant here because the logistics of necessity always imposes similar conditions upon men who must fight in a featureless region. If, even in the atomic era, gases still react as Newton perceived some 300 years ago, may we assume that the factors which condition warfare have broken with Mahan?

Presidents of Local Posts of the

E. B. Cummins
Aberdeen Post

William W. Juvenal
Albuquerque Post

Richard M. Donahue
Birmingham Post

A. A. K. Booth
Capital Cities Post

Col. Eugene A. Romig
Florida Post

Stanley C. Hope
Hartford-Springfield Post

G. E. Nicholson
Mid-Continent Post

Harry Darby
Midwest Post

Williard L. Love
New Orleans Post

Leslie R. Groves
New York Post

Marmion Mills
Puget Sound Post

M. A. Fraher
Quad Cities-Iowa Post

Maj. Gen. W. E. Laidlaw
Rio Grande Post

Harold F. Silver
Rocky Mountain Post

Association

The local Posts of the American Ordnance Association, located in industrial, scientific, and educational centers throughout the United States, are a vital factor in the Association's task of fostering industrial preparedness.

These Posts by their meetings, seminars, plant visits, and similar activities keep alive an interest in the continuing need for scientific and industrial know-how in the production of the weapons of defense. The presidents of these Posts, most of whom are shown below, are the key men in this nationwide effort for peace.

Thomas Drever
Chicago Post

R. S. Gruver
Cincinnati Post

Albert J. Weatherhead, Jr.
Cleveland Post

Ralph F. Peo
Empire Post

Raymond C. Blaylock
Lone Star Post

Patrick W. Lizza
Los Angeles Post

James A. Ward
Louisiana Post

Del S. Harder
Michigan Post

Glenn E. Seidel
Northwest Post

Everett B. Webster
Philadelphia Post

William K. Fitch
Pittsburgh Post

George W. Brown
St. Louis Post

William E. Butts
San Francisco Post

Kenneth P. Campbell
Texas Post

F. B. Reybold
Washington Post

The Age of Nuclear Power

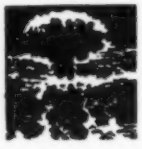
The era of coal and oil is drawing to a close, and we are now on the threshold of a new period of great scientific advancement requiring increased understanding of our moral responsibilities

Dr. C. A. Coulson

IN the year 1911 Lord Rutherford—or Professor Ernest Rutherford, as he then was—discovered the nucleus of an atom. Eight years later, in 1919, at Manchester University, he made the further startling discovery that this nucleus could be broken in two parts if a suitable atomic bullet (an alpha particle) were used.

The experiments themselves were made toward the end of World War I, and when he wrote about them to an American friend shortly afterward he suggested rather whimsically that the influence of this discovery on the course of world history might turn out to be greater than that of the war that was just concluding.

Such a claim would have appeared fantastic to most of his contemporaries. But a few years ago, when I was visiting Japan and saw some of the effects of atomic explosions, I realized that he was right. For better or worse we are now in the Atomic Age—our thoughts, our plans and, indeed, our very survival are bound up with this new situation.



This is one of the great moments of history. It is not the first great moment, even if we restrict ourselves to mechanical and scientific inventions. But its effects are likely to be no less far-reaching than its predecessors, and certainly it has come upon us more suddenly. For even if we date the beginning of the Atomic Age to as early as 1919, that is a small period—less than forty years—for us to be able to see something of the pattern of the future.

Dr. Coulson, a well-known British nuclear physicist, is Rouse Ball Professor of Mathematics at Oxford University, Oxford, England.

The age of mechanization, which is usually associated with what we call the Industrial Revolution, was a gradual one. It took fifty years before Michael Faraday's discovery of electromagnetic induction was put to practical large-scale use in the form of commercial dynamos and motors.

But it took only three years from the discovery of nuclear fission by Hahn and his colleagues in Berlin to that strangely magic date, December 2, 1942, in a squash court in Chicago, when Enrico Fermi and his research team freed the atom's energy for human use—and in another three years atomic bombs had been dropped on Japan.

We are indeed living in revolutionary times. It is important that we should realize this and recognize that such a situation brings with it new and difficult decisions. Many of these—such as the precise scale on which we should build atomic-energy plants, and their particular form—are purely technical and scientific decisions. But others, as we shall see, are of a quite different kind and require from us a moral judgment.

It is for this reason that too great a preoccupation with the purely scientific aspects of nuclear energy may even hide from us the real significance of the changes that are taking place.

For several years during the war I lived in the Scottish city of Dundee. As I looked at its ugly, overcrowded, unsanitary tenement houses, I could not help being aware of the earlier Industrial Revolution. It came to Dundee in the form of the jute industry, and because no one was big enough to see what was happening, cheap female labor was imported and slum property was built.

ITS legacy today is one of the highest percentages of ill health and infant malformation anywhere in the British Commonwealth. Yet no one would argue that the introduction of machine looms was evil. What was wrong was the absence of an imagination which could see the growth of industrialization in its full terms. The science was good, but the moral judgments were bad.

A choice of this kind is nearly always associated with great moments in history. Side by side with those atomic explosions over Japan, I put the opening a few months ago of the large full-scale atomic power station in northern England, soon to be followed by others

in several different countries. Good and bad seem to be very closely associated one with the other.

In Scotland you will often find people pointing out that their two great national rivers, the Forth and the Clyde, have their sources within about a mile of each other. But although they start almost at the same point of space, they flow to the sea in very different ways—the Clyde westward via Glasgow and the Forth eastward via Edinburgh.

I AM desperately concerned that standing as we do at this watershed in history, we shall see big enough and then do the right thing.

This is not easy. There is an old Chinese curse: "May it be your fate to live in interesting times!" It reminds us that it is far more difficult to act rightly when the possibilities are so great and so exciting than when we live in more gentle days.

It may help us to see the sort of thing that I mean if I refer briefly to two or three situations which are now presented to us and which come in terms wholly different from anything we could have anticipated only a few years ago.

First let us consider the change in armaments. The pages of ORDNANCE bear eloquent witness to the new dimension in which we move. I am writing these very words on the same morning that my newspaper reports the nonstop round-the-world trip of three B-52 jet bombers in less than two days. Well might Gen. Curtis E. LeMay, Commander of the U. S. Strategic Air Command, describe this flight as "a demonstration of the Command's global capabilities to strike any target on the face of the earth."

I AM proud to be alive in a time when men can plan and carry through such projects. But I cannot get out of my mind that these planes are designed to carry hydrogen bombs. And I recall the words in which Group Captain Cheshire, one of the two British observers at the bombing of Nagasaki, described his own reactions to the whole event:

"When Wilhelmshaven blew up we felt a sense of elation. We had set out to destroy, and we had destroyed. When Nagasaki blew up, we felt nothing but an overwhelming sense of awe, not because an unusual number of Japanese had been killed, but because something had happened which altered our fundamental concepts of life."

It is not for me here to argue the case for or against the continued stockpiling of nuclear bombs, but I must say that I was considerably impressed by a statement prepared by Thomas E. Murray, one of the members of the Atomic Energy Commission, presented before the Senate Subcommittee on Disarmament at Washington, D. C.

In this paper, which was printed in full in the September-October 1956 issue of ORDNANCE, Mr. Murray claimed that "at our present distance from that disastrous event, I do not think that the use of this bomb against this particular target—the city of Hiroshima and its multitudes of innocent people—could be justified on moral grounds."

If words like this can be used ten years after the event, what will be said in another ten years about our present attitudes? I do not know. But I do know this: that it is high time we cleared up the muddle in our own minds about the use of large-scale nuclear weapons.

What I have just been saying is, in some respects, the negative side of this particular issue, and it would be very wrong for us to forget the more positive side. I have just referred to the newspaper report of the round-the-world trip of the B-52 jet bombers.

Now it just happens that immediately opposite this anouncement is the confirmation of a report that has been widely believed for some time—that Great Britain is to double or treble her atomic power station construction.

How ironical it is that the very country in which the first Industrial Revolution had its birth should become the first to recognize that the very future of its industry now depends on changing over from coal—on which that revolution was built—to nuclear power.

Yet the facts are clear: the era of coal and oil is drawing to an end, and the rate at which this end is being approached is daily increasing. Even the United States, rich though it is in oil, uses more than it produces and has to depend on imports.

BUT the situation is certain to grow worse. For oil and coal represent power. And without power civilization is doomed. Without power our automobiles and our streetcars and our airplanes would not move, our factories would be idle, our homes would be cold and dark. Without power we should be back in the Middle Ages. The consumption of power can be used as a measure of the degree of industrialization in any community. In a heavily industrialized community like the United States the per capita use of power is equivalent to about nine tons of coal a year; in an underdeveloped community like India or China it is a

Fireball from history's first atomic artillery shell fired May 1953 (Army photo).

bare five hundredweight. We simply cannot understand what is happening in the world around us unless we see it against this background.

My newspaper today describes the opening of the world's longest dam—the Hirakud Dam in Orissa, India—which is three miles long and will conserve the waters of the Mahanadi or Great River for the development of hydroelectric power.

THIS is by no means the only one of these projects which Mr. Nehru calls "the temples where I come to worship." And the same newspaper reports the start of negotiations between the Japanese Government and Britain for the possible purchase of a complete atomic power station.

Yet this is but the beginning of the demand. Is it likely that all the teeming millions in India and China will be content to see the civilization of the West, with its large resources and larger use of power, and do nothing? Of course there will be revolutions and threats of war while disparities exist.

In days gone by the underdeveloped countries would hardly have known of the way of life of the developed ones; but that is no longer true, and it must now be one world or none.

There is going to be a terrific demand for power. We are now using it ten times as fast as a hundred years ago. But such is likely to be the rate of increase in demand, as the backward countries become industrialized, that in another fifty years we shall need twenty times as much each year as now—and where can so great a supply be found? Oil would hardly last a single decade at this rate, and coal a bare century. There simply is no present alternative to using nuclear power.

THIS is why Professor Bhabha, the Indian physicist, could say in his presidential address to the United Nations Conference on the Peaceful Uses of Atomic Energy at Geneva eighteen months ago: "For the full industrialization of underdeveloped countries, for the continuance of our civilization and its further development, atomic energy is not merely an aid—it is an absolute necessity."

Now we can begin to see that this is essentially a moral and ethical problem. Few of us would wish to claim that we in the West were meant to have a permanently higher civilization than those in the East. So the difficult discussions about where to build atomic power stations, how to finance and staff them, how to make available for all men everywhere the blessings of a truly free civilization—these discussions are urgent. They admit of no facile solution, and they show that at rock bottom you cannot separate man's science from his religion.

We often discuss "armament for national survival." When we do so, we should do well to realize that atomic power will figure in our discussions, not just as a warhead to some ICBM but as one of the great tools in implementing the Four Freedoms—freedom from fear, freedom from want, freedom to work, and freedom to worship.

I should like to see the nations of the world recognize their common peril and face it together. It is not sheer idealism to admit that working together in a joint enterprise that we all know to be of first-rate importance is one of the best ways of creating mutual trust. The story of the latter years of the war, and the breakdown of fellowship after it when there was no great enterprise to hold us together, is evidence of this.

I BELIEVE that a project to use the benefits of nuclear power on a world scale would do more to establish good relations and ensure peace than interminable argument about the control of fissile material.

Let us dream our dreams—and then make them come true—of evaporating sea water and transporting it to irrigate the arid parts of northern Australia; of blasting a way through the mountains to water the deserts of the western United States; of changing the climate of Siberia; of opening up the new continent of Antarctica.

These are dreams today, but tomorrow, if they were to become actualities, they might prepare our minds and hearts to inherit the earth as one human race at peace with itself, conscious of its power, and accepting the responsibilities that accompany that power.

I have spoken of power as if it were important—and so it is. But there are other aspects of our nuclear age that must not be forgotten. Madame Curie purified eight tons of pitchblende, and after four years all she could extract was only a single gram of radium.

BUT the burning of one pound of uranium in a nuclear pile produces radioactivity equal to about half a ton of radium. If we really wanted to do so, we could use this, and other medical discoveries, to wipe out many of the endemic diseases of the tropics. We have already used it to produce new varieties of oats and other cereals, better adapted to weather conditions. We have learned more about the biochemistry of the body's metabolism in twenty years than in the previous hundred.

Here is the making of a new crusade, far more effective than those early inconclusive ones of the Middle Ages. President Eisenhower's "Atoms for Peace" movement, with its generous offer of help to underdeveloped countries, is one noble element within it. So is Britain's sending out each year 5,000 parcels of radioisotopes to all parts of the world to cure disease and help in medical research.

But these are not enough. We need an all-out attack on all those things which prevent man from achieving his full human status. This is a time for greatness. And that means not only physical greatness, where most folk who know would admit that we have been pretty successful, but also moral greatness—not being afraid to face delicate and difficult questions to which, if we are honest, we shall have to admit that we don't yet know the answers.

THE atomic age—of nuclear knowledge and nuclear power—is only meant for those who look at things, and decide, and act, in a big way. It was the activity of man's mind that saw these great possibilities and conceived the taming of the atom. It was man's physical prowess that acted on this knowledge and made the dream an actuality. It must be man's spirit which, sensitively, imaginatively, coöperatively, even gropingly, plucks out of this possible disaster—peace.

Crisis in Brain Power

The inadequate number of trained scientists and engineers turned out by the United States will inevitably result in both economic and military catastrophe unless steps are taken to remedy the situation immediately

John H. Heller, M.D.

WE in the United States pride ourselves on our ability to rise rapidly and massively to a challenge such as a major war. There are, however, two categories where no amount of effort, no amount of money, no amount of self-sacrifice can compensate for an inherent lack. The first is an inadequate number of trained scientists and engineers; the second is the knowledge produced by such men.

At the moment of this writing, we have not enough engineers and scientists for our own economy.

According to the Joint Committee on Atomic Energy, Subcommittee on Research and Development, in its report on "Engineering and Scientific Manpower in the United States, Western Europe, and Soviet Russia," in 1955 we produced 23,000 scientists while the Russians produced 56,000—most of them even better trained than ours.

Listen to the voices of some of those who have weighed the problem.

States Gen. N. F. Twining, Air Force Chief of Staff: "The qualitative battle of any World War III is being fought right now in our laboratories. Whether we like it or not, we are in a technological race that we cannot afford to lose. If being ahead is related to numbers of aircraft and combat units, we are not ahead."

States Dr. J. H. Hildebrand, President of the American Chemical Society: "If we let them get ahead of us in education, the national disaster for us and our way of life is inevitable."

Dr. Heller is executive director of the New England Institute for Medical Research, Ridgefield, Conn.

Adm. Lewis L. Strauss, Chairman of the Atomic Energy Commission, states: "Unless immediate steps are taken, a situation, already dangerous, within less than a decade could become disastrous."

Allen W. Dulles, Director of the Central Intelligence Agency, predicts that the Soviets will graduate 300,000 more university students in the basic physical sciences than the United States in the next decade.

The first part of the problem must be subdivided further—scientists and engineers can be divided roughly into three groups. The first and smallest, and yet most critical, is comprised of those who produce new knowledge. These are the investigators who work in basic research. They are the scientists who pioneer into the unknown and roll back frontiers.

Because of the rigors and complexities of such work, most of these scientists must have advanced training and a doctorate degree.

The second group consists of those who have a bachelor's degree in science or engineering. It is this group that takes the new knowledge developed by the first group and converts it into usable or applied forms.

The third and final group consists of the technicians. These are usually men who do not have university or college degrees but who are specially trained to execute the applied research into its final form.

IN the field of engineering as used here are included:

(1) Chemical engineering including fuel and petroleum technology; (2) Civil engineering including architecture and building; (3) Electrical engineering including electronics; (4) Mechanical engineering including aëronautical; (5) Metallurgical engineering including metallurgy; (6) Mining engineering; (7) Others, including general engineering.

It is of interest to note what has happened in the number of engineers graduated with a B.S. degree in the United States versus Russia between 1950 and 1955.

Year	*Engineers Graduated with B.S.*	
	U.S.A.	*Russia*
1950	52,732	28,000
1951	41,893	29,000
1952	30,286	30,000
1953	24,164	40,000
1954	22,236	53,000
1955	23,000	63,000

In 1955 alone, it was estimated that

the American economy required 12,000 more engineers than were graduated.

The following list of doctorate degrees awarded in 1954-1955 in the United States in engineering fields is eloquent testimony of the shortage:

Mechanical, 79; electrical, 141; civil, 29.

LET us now look at what is known of the caliber of the Russian engineer compared with ours. The Russian technical schools are rated as excellent. For instance, the Bauman Higher Technical School in Moscow is rated better than any school in the United Kingdom. A comparison between Bauman and American schools shows that all the engineering students at Bauman take physics courses which correspond in level with those taken by physics majors in the United States, and which are rarely taken by U. S. students.

At Bauman, out of a total of 4,848 hours spent on instruction, laboratory work, and practical study, 4,322 are devoted to scientific subjects. For purposes of comparison, at Massachusetts Institute of Technology, the curriculum prescribed for similar mechanical engineering students includes 2,895 hours of instruction and laboratory work.

Let us examine briefly an example of the Russian effort in the field of aviation. The Soviets have seven aviation institutes that give a 5½-year degree. Currently, these institutes are turning out about 2,000 graduates a year. The estimated output of equivalent U. S. engineers is about 750 graduates a year.

The Soviet institutes train their engineers in aircraft structure, engines and propulsion devices, service and flight control equipment, aircraft armaments, aërodynamics, hydrodynamics, heat transfer, gyros and stabilization devices, ballistics, electronic control devices, automation techniques, etc.

THE tremendous reliance that the entire economy and military strength places in the hands of creative scientists—those who produce new knowledge—cannot be overemphasized. The Russians know this all too well. By mid-1955 they had 15,000 more doctorate-level scientists than we.

"Most important of all, . . . the basic research now being carried out in Russia is not being hindered or confused with applied, industrial, or military research."

Let us look at our current output of doctorate scientists. In 1955, in the increasingly important field of astronomy, we produced 16. In the critical field of mathematics, the entire United States output was 250 men. In meteorology, in 1955 the total number of doctorate-level scientists produced in the United States was exactly two men!

Chart 2 sums up the total data in higher degrees in science in the United States versus Russia.

It must be remembered that another ominous aspect of Soviet superiority in numbers of scientists and engineers lies in the cadre of professional people they have available for export to neutralist countries, uncommitted areas, and even—if we cannot supply the talent—to our friends.

It is not astonishing that the Russians have achieved the scientific and technological level which they have now attained. Since 1917, their materialistic outlook has made them dedicated to this end. Today, out of sixty-seven members of the U.S.S.R. Council of Ministers, thirty-nine have had a scientific or technical education. Most important is the fact that nine out of the thirteen First Deputy and Deputy Chairmen have a technical background. Such men know the value of technology and are in a position to render any material aid wherever and whenever it is needed.

Russian achievements in research are such that American scientists returning from visits to Russia state that the Soviets excel in areas important to national power and military strength. For instance, their "work in combustion phenomena and chemical kinetics is probably the finest in the world, and they are highly competent in low-temperature physics research."

They have recently demonstrated a number of high-speed electronic digital computers, at least one of which—the BESM—is equivalent to the better high-speed computers in the United States and United Kingdom. Nesmeyanov, president of the U.S.S.R. Academy of Sciences, has announced that high-speed computer research is one of a number of areas of fundamental importance in which the Soviets will concentrate their efforts as, he stated, research in this field is likely to lead to a scientific break-through.

IN reporting the reactions of two American physicists who recently returned from Moscow, Dr. R. E. Marshak, head of the physics department at the University of Rochester, and Dr. R. R. Wilson, who directs the laboratory of nuclear studies at Cornell University, it can be pointed out that both men were impressed by the great sense of urgency and dedication that the Soviet scientists manifest in their high-energy physics research.

They felt that the atmosphere in Russia was reminiscent of that felt at Los Alamos at the time of the Manhattan District Project. No thought is given to cost; the major emphasis is speed. Several of Russia's nuclear machines are considerably more powerful than anything in the United States. Currently, they are building a 10-billion-volt proton synchroton, which for several years will be the most powerful machine in the world. Already planned is a 50-billion-volt device which will be more powerful than anything the United States is even contemplating.

IN the field of the 5-foot "atom-smasher"—the cyclotron—which takes about three years or more to build in the United States, the Russians are "mass producing" them in one year!

Most important of all, it was emphasized that the basic research now being carried out in Russia is not being hindered or confused with applied, industrial, or military research. The Russian leaders apparently feel that their economy is strong enough to afford both, and they feel a dedication to the importance, the criticalness, and promise for the future which only basic research can bring.

Now that the problem has been outlined, we must analyze why the United States is in this critical situation and how we may extricate ourselves. As with most crises, there is more than one cause. Unlike most other crises, all the causes can be specifically delineated.

The desire to go into science or engineering usually begins very young. American youth is surrounded with technology to a greater degree than any other country in the world. Science is glamorized to the child—space travel, science fiction, etc.—in movies, on television and radio, in comics. With our huge use of mass communication media, our children probably receive the world's greatest stimulus to enter the field of technology. But somewhere, between childhood and college, these potential scientists and engineers are lost in droves.

IT is in the high schools that we find the first answer as to how our scientific and engineering crisis has evolved. There are two principal reasons:

(1) The high schools are not adequate in their requirements for science and mathematics; and (2) there are not enough high-school science teachers, nor are many of them adequate.

The high schools no longer provide the courses in science that they used to. For instance, courses such as astronomy, meteorology, and geology, previously included in high-school curricula, have virtually disappeared. In the year 1890, 22.21 per cent of U. S. high-school students studied physics. In 1952, only 4.3 per cent took this subject.

In 1890, about 10.10 per cent of the American high-school students were taking chemistry. By 1949, it had fallen to 7.6 per cent. Not only have the relative values fallen, but the absolute numbers have declined. In 1943, there were 651,000 students studying chemistry in high school. By 1954, the number had decreased to 595,000.

IN mathematics, the pivotal and keystone subject, the attrition over the years has been most serious of all. Note the following table showing the percentage decline in students taking this subject.

Year	*Algebra*	*Geometry*
1900	56.3%	27.4%
1910	59.5%	30.9%
1949	26.8%	12.8%
1953	24.6%	11.6%

Hence the high schools are permitting more and more students to avoid science and mathematics and to take easier and less "strenuous" subjects. The apparent fear of educators and parents that their children's brains may be overstrained in high school is both ludicrous and nationally calamitous.

The student's predilection for the "easy way" and the desire for "gut courses" to get high grades for admission to college with adult concurrence or encouragement are major factors in our scientific shortage. More than half of the high schools of the United States do not teach physics at all; half of our high schools do not have courses in chemistry.

Let us note what the Russian counterpart of the American student is doing. First of all, he attends school six days per week and is in school until almost 5 p.m. every day. Mathematics and science are of major importance in Russian schools. Of class instruction time in Soviet schools, mathematics and science occupy 28.5 per cent in the elementary grades, 36.3 per cent in the intermediate grades, and 40.8 per cent in the upper grades.

THE pace of school work in Russian schools has been described as "far more rigorous than any encountered in the United States."

During the 10-year period of Soviet schooling, the students receive approximately the same number of hours of instruction as U. S. students receive in their first twelve years of school.

In America, the high-school science teacher situation is adequately summed up by a recent headline in *The New York Times,* which stated, "Six hundred and fifty mathematics teachers needed by New York City schools."

The article further went on to say that only 88 teachers were available to fill the 650 vacancies. Of these 88, only

Chart 1. A 1955 curriculum for mechanical engineers at a top Russian school.

Subjects of instruction	*Number of hours spent on subject over 5-year period*
Higher mathematics	388
Physics	245
General chemistry	120
Descriptive geometry	90
Machine construction drafting and drawing	188
Theoretical mechanics	214
Strength of materials	232
Theory of mechanisms and machines	198
Machine details	215
General electrical technology and measurements of nonelectric magnitudes	190
Hydraulics and hydraulic machinery	84
General heat engineering	78
Physical metallurgy and heat treatment of metals	96
Technology of metals (metallurgy and hot fabrication)	118
Shop training	204
Interchangeability and technical measurements	68
Material handling machinery and mechanisms	116
Metalworking machine tools and automatics	337
Hydraulic equipment in machine tools	56
Electrical equipment in machine tools	65
Metal cutting	80
Metal cutting tools	221
Machine construction technology	208
Construction of mechanical equipment	39
Planning of machine building shops and elements of structural engineering	65
Thermal treatment of machine details	39
Automation of industrial processes	65
Industrial economics and organization and planning of enterprises	91
History of engineering	39
Safety engineering and fire protection engineering	39
Foreign language	134

Total number of hours spent on scientific subjects is 4,322 out of grand total of 4,848

75 were eligible for the job. A recent survey of thirty States showed almost half of the mathematics and science teachers had been trained to teach music, home economics, or physical culture and had to be drafted to teach science because no one else was available.

Good science teachers find that industry will be happy to pay about twice their teaching salary. In addition to the problem of salary, high-school science teachers all too frequently find themselves rebuffed as they try to maintain some contact with laboratories of industry or the university. The English teacher has new knowledge available and only as far removed as the local library.

THE science teacher is not so fortunate. New developments in science appear in highly technical weekly, monthly, or quarterly journals. There are several thousands of these journals —all costly—and hence not available except in university or equivalent libraries. Thus these sources are virtually inaccessible to most secondary science teachers and, even if available, are usually too technical and complex for their comprehension.

Deprived of adequate salary when better money is available, and robbed of the intellectual stimulus essential to all those truly interested in the field—it is little wonder a shortage exists.

At about the high-school level, economic factors enter in. It is found that twenty per cent of the top quarter of American high-school classes never graduate. They have to go to work. In addition, only forty per cent of the top quarter, that might be expected to go into science, go on to college. Of these, only forty per cent, who enter college as potential scientists and engineers, are able to finish.

When the potential scientist or engineer reaches college, a variety of influences begins to affect his outlook. First, there is the professors' influence on the students. Depending upon the quality of these individuals, they can play an enormous and definitive rôle in the student's life. Most professors—aware of the importance and challenge of scholarship—will constantly be on the lookout for competent students who might be persuaded to go on to higher degrees in scientific subjects.

"Russian achievements in research are such that American scientists returning from visits to Russia state that the Soviets excel in areas important to national power and military strength. For instance, their 'work in combustion phenomena and chemical kinetics is probably the finest in the world, and they are highly competent in low-temperature physics research.'"

At this point the student usually begins to equate scholarship and dollars. One can hardly blame him for doing so, and it is obvious why only about 6 out of every 1,000 science-minded high-school students ever go on to an advanced degree.

First of all, the student becomes aware of the number of competent faculty members who are continually leaving for much better paying jobs in industry. This tends to distort the scholarship-verses-dollar equation from the very first.

One major Eastern university was chosen for the purpose of illustration. Today, an engineer graduating from a typical university at the age of 21 or 22 with a B.S. degree can command as a beginning salary as high as $6,000 to $7,000 per annum. By the time he is 27 years of age and has worked for 5 years, he can receive, in the Pittsburgh area, up to $12,000. His total earnings for the five-year period will amount to between $40,000 and $45,000.

Contrast this with his economic future, should he decide to go on and receive his doctor's degree, and join a university faculty. Initially, he will probably have to spend about $1,000 to $2,000 per annum for the 3 to 5 years that it takes to obtain his degree. If he achieves a post as an instructor on the university staff, he will find himself fortunate to obtain a salary of perhaps $4,500 to $5,000 at the age of 27.

If he stays on the faculty, it may take approximately twenty years to reach a full professorship. Some salaries of full professors in science at the same university that gave the above figures are as low as $6,500. In an effort to try to meet the situation, this same university is attempting to raise the minimum salary for a full professor to $8,500.

Whereas certain very few major universities have a significantly higher salary for their full professors, there is no comparison to the earnings of a man of equivalent age and tenure in industry—only contrast.

Again, let us pause to look at the Russian counterpart. As mentioned earlier, Dr. Robert Wilson, director of the Laboratory of Nuclear Studies at Cornell, has recently returned form Russia. He points out that the professor of physics in Russia will have as his basic salary 30,000 rubles a month. At the present official rate of exchange, this amounts to $90,000 per annum.

In addition, he gets 6,000 rubles a month for being a member of the Academy. Other remuneration is available for auxiliary positions in industry. Hence his salary is over $105,000 a year. If we assume the ruble is worth only a third of the official rate, the professor's salary is still about $36,000 a year—a figure which makes the preceding figures for American professors a mockery.

PERHAPS the most realistic evaluation of the economic worth of the Soviet professor is to compare his 30,000 rubles a month with the Soviet unskilled laborer's salary of 600 rubles a month, or the skilled laborer's salary of between 1,000 and 1,200 rubles a month. Contrast these figures with American skilled laborers' annual earnings and those of our full professors.

As important as the financial aspect is their position in society and the esteem in which Russian scientists and professors are held. Dr. Wilson points out that there is a marked and glaring difference between Russia and the United States in this regard.

To return to the American engineer or scientist, it is clear why his choice will be for industry and dollars rather than the university and scholarship.

However, even in industry, the scientist's or engineer's future is limited. That is, it is limited as long as he

practices his profession. If he moves into sales or administration, he may become president of the corporation. Hence, even here, as long as the scientist remains in the laboratory, his income and position are pegged.

The importance of this factor can be seen from the fact that fifty per cent of the engineers graduated from the Yale Class of 1946 were no longer practicing their profession ten years later. This is not because the law of supply and demand has failed, but rather that even in this current shortage the engineering pastures are still not as green as other fields.

SELECTIVE Service in the United States has taken certain steps designed to conserve and presumably even encourage scientists and engineers. If a certain academic average is maintained, a student is allowed to finish his scholastic work. If he moves into work deemed "defense work," he may be deferred. If not, and if he is on a list of critical skills, he is drafted for 6 months and then serves 7½ years in the Reserves.

Serious questions as to the success of these policies are being raised. For instance, the Subcommittee on Research and Development of the Joint House and Senate Committee on Atomic Energy states: "There are deficiencies in the military draft policies as they affect college students. Selective Service deferments should not be regarded as granting privileges to a few, but as a means of enhancing the security of the many. Engineers and scientists constitute less than one-half of one per cent of the population. Yet, this limited group is relied upon to advance the standard of living, to create new and ever more powerful military equipment and, in general, to be responsible for our national security."

DR. Howard A. Meyerhoff, executive director of the Scientific Manpower Commission, states: "Industry failed to get all the scientists it needed in 1953 and again in 1954, when there was a further decline of four to five per cent in the number of scientists graduating with bachelor's degrees. The dwindling numbers must have been a factor, but other factors cannot be ignored—for example, the heavy drain for military service, especially after Korea, when many deferments were terminated."

Dr. Nicholas DeWitt, author of the definitive volume, "Soviet Professional Manpower," states that in "certain fields, Soviet students, unlike their counterparts in other parts of the world, are not subject to military service or to disturbances incident to military mobilization. This applies even though universal military training has been the law since the early days of the Soviet Union."

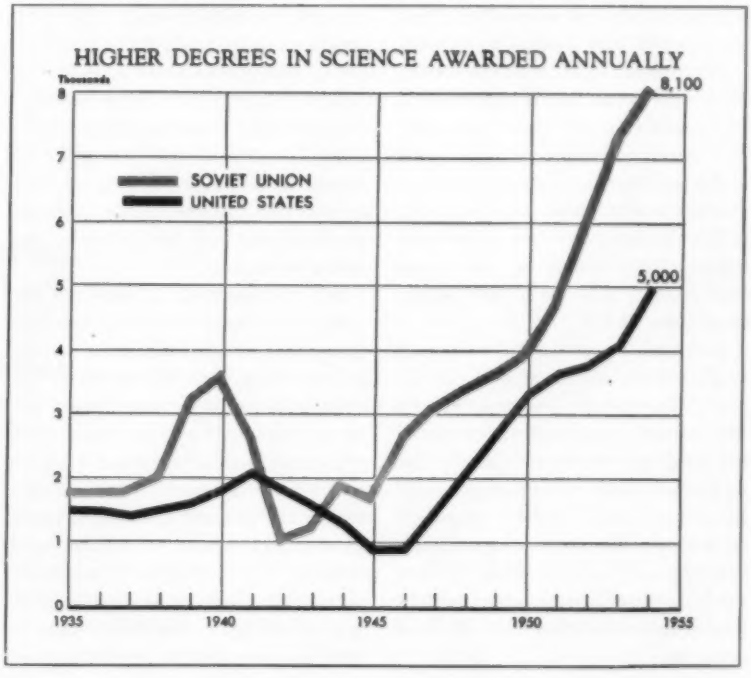
There are currently eighty-five institutions of higher learning in the Soviet Union whose students are completely immune to military draft and remain so the rest of their lives unless they leave their professions. This law was put into effect in 1943 and has remained in effect ever since.

According to the Joint Committee on Atomic Energy, Subcommittee on Research and Development, of the scientists lost in 1953, ten per cent was due to military service. In a still later report, July 1956, the same subcommittee states, apropos of the use of scientists in the armed forces:

"There are still some 5,000 or more specialists in the service who are 'lost' in the enlisted ranks doing routine chores such as K.P. duty. Vigorous efforts should be made to locate these highly skilled men and action taken toward either assigning them duties and responsibilities commensurate with their scientific talents or providing for their early release from the compulsory 2-year tour of duty."

THE report goes on to say: "Considerable improvement can also be made in the R.O.T.C. program. At present, little attempt is made to assign young officers with scientific and engineering backgrounds to the duties for which they have been prepared. The compulsory 2-year tour of duty for officers with these skills is largely wasted time and often results in failure of the exceptional student in the R.O.T.C. to continue his studies for an advanced degree. Perhaps the setting up of a separate scientific corps within the armed services would help ensure more intelligent utilization, both in enlisted and officer ranks. Or consideration might be given to creation of a scientific personnel board with review power over both Selective Service and over the use of scientists in the service."

Chart 2. Comparison of U. S. and Russian higher science degrees awarded.



The final phase I want to discuss is that apparently mysterious area called basic research. This is apparently an inordinately difficult concept to convey to nonscientists. Basic research might best be defined as a quest for new and fundamental knowledge not specifically related to any application. Though colleges and research institutes know the immense importance of basic research, few, if any, such institutions can provide money for any such research from their own funds. Hence, they must go to business or government.

When the investigator does so, and states he wants to pursue a problem in basic research, the businessman and the legislator usually ask the question, "Well, if it's not related to any specific application, what good is it?" The answer is that every application in every field derives from some basic discovery and, of course, the basic discovery must come first.

TRANSISTORS came from basic research in solid-state physics. Similarly, nylon came from fundamental work in polymer chemistry. The atomic age and all its works came from basic work in theoretical and nuclear physics. However, even after this concept is made clear, the businessman or legislator would like, if not a guarantee of results, at least a finite end-point to the basic research which he is asked to support.

The research man must then state, "If I knew what the end-point would be, I wouldn't have to do the research." This usually terminates any willingness of the businessman to support basic research. He will admit that "in theory, it sounds fine but—" he won't contribute funds because he cannot see basic research in terms of profit or loss on a ledger sheet.

Both U. S. business and the Congress apparently feel the same way. Of 15,000 U. S. concerns which put money into research, less than four per cent of the funds go into basic research. The most minute part of any congressional research appropriation is for fundamental research. This is paradoxical when our economic future and our military survival depend on new scientific knowledge—obtainable only by basic research.

Many of the solutions of the specific problems mentioned are self-evident. It is, however, not enough to acknowledge the existence of solutions. They must be acted upon with the greatest conceivable speed. It must be a crash program in velocity and intensity, but it must be sustained and maintained as this Nation's blood of the future. If we could remedy our high-school faults and gaps tomorrow, it would be close to a decade before the product of this change—new scientists—are available and productive.

FIRST, the high schools must provide more and better courses in mathematics and science. More of these courses must be made mandatory instead of elective. English is mandatory, and it is no less important for a citizen of the technological age to have a modicum of understanding of science than it is for a scientist to have an awareness of Shakespeare, Milton, and Spenser.

Next, the caliber of high-school science teachers must be improved. There are several ways to approach this problem. Science teachers can be given more income without specifically raising their school salaries. This can be done by having local or regional industry provide for summer employment of these instructors in scientific jobs. Added income and experience would result. This program can be in addition to or alternating with the provision by industries and government of summer fellowships for high-school science teachers to go to colleges or research institutes and take courses to broaden their horizons and deepen their understanding. It is incumbent upon such institutions to provide such courses.

It is proposed that industry reinvest some of its profits in the institutions that are the fundamental source of those profits. Perhaps, under the leadership of some major corporation, a fund can be set up for the multiple purpose of supporting both faculties and basic research. Each member firm might contribute to this fund an amount predicated on the number of engineers and scientists that it employs. Thus, if only 50 per cent of the corporations employing technological manpower contributed $200 per annum per engineer or scientist, there would be $50,000,000 a year which could be used to strengthen faculties and support basic research. Congress might be willing to match this amount.

School and scientific loyalties being what they are, I imagine recruitment of college graduates by nonmember industries would become quite difficult. Hence, practical as well as moral suasion for the nonparticipating industries to join would be great.

In such a manner, industry and government can increase and perpetuate top-caliber teachers and investigators and support basic research from which all will profit.

Whereas many caveats must be borne in mind in any discussion that has such sweeping generalizations, yet the basic problems remain as stated. Noted educators have suggested that we should be more worried about quality of scientists and engineers rather than quantity. Unfortunately, the Russians appear to be getting both.

OTHERS have stated that the almost complete emphasis on technical subjects in engineering school and the lack of humanities will tend to make the Russian engineer and scientist one-sided and will tend to suppress his imagination. Others have warned that one cannot make a completely fair comparison between different types of American and Soviet graduates. Though these and similar cautionary statements are valid, they do not mitigate the ominousness of the technological race between the United States and Russia. It is a race we must win.

There are many isolated instances of corporations and institutions, such as the National Science Foundation, which are attempting to improve the high-school situation and the basic research picture. The efforts, in comparison with the problem, are still but a token.

The United States, along with the rest of the world, is entering into a technological age which will involve the total warp and woof of the national fabric. Upon its strength depends our economic future and our military security. Ignoring our dangerous shortages and shortcomings is as foolish economically as it is militarily calamitous.

Single Side Band for SAC

The advantages of covering round-the-world distances with high-frequency voice radio with less power than that required for the low-frequency range are now being utilized by the Strategic Air Command in its mission

Maj. Gen. Francis H. Griswold

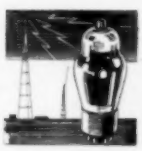
"SCREWDRIVER, Screwdriver. This is Hound Dog, Hound Dog. Radio check. How do you read me? Over."

"Hound Dog, Hound Dog. This is Screwdriver. Read you loud and clear. How me? Over."

"Screwdriver. This is Hound Dog. Roger, Roger. Read you loud and clear. Fishpole, Fishpole. This is Hound Dog, Hound Dog. Radio check. How do you read me? Over."

By following procedure such as this every thirty minutes throughout the twenty-four hours, an Air Force radio operator, a member of the Strategic Air Command, maintains quality voice contact with other stations in his net.

These stations are located at key SAC control centers, both within the U. S. continental boundaries and at overseas air bases. These include SAC Headquarters itself, located at Offutt Air Force Base, near Omaha, Nebr.; on east and west coast SAC air bases; near London, England; at Thule, Greenland; North Africa; and on Guam.



Their primary mission is to give the high quality of communication service necessary for the top group of SAC commanders to control and coördinate aircraft operations. This service is not only considered essential by these commanders but also provides an alternate means to telephone, teletype, and air-to-ground radio communications.

It is almost needless to state the exacting requirements of speed, flexibility, and fidelity that such a communication service must fulfill. To demand that this service transmit the "word" at any time, accurately, and with no delay, then receive a bona fide acknowledgment immediately, from any one or all the receiver stations, and with defense security restrictions imposed, if need be, is almost fantasy.

General Griswold is Vice Commander in Chief, Strategic Air Command, Offutt Air Force Base, Omaha, Nebr.

Further, people acquainted with radio operations know that the problems of distance, propagation fluctuations, and atmospheric and man-made interferences must all be resolved in order to yield results that can approach those using wire line or link type communications. The last requirement demands coverage for worldwide aircraft operations.

Yet the Strategic Air Command believes that the best answer today to meet these requirements is found in single side band (SSB) radio equipment operation. This transmission process concentrates the transmitted energy into the selected side band of the modulated radio frequency, suppressing the carrier and eliminating the other side band, resulting in a theoretical eight-fold power increase in the intelligence-carrying part of the radiated energy.

The normal bandwidth of the carrier frequency is cut in half. This permits the use of twice as many radio stations for a given frequency range. This is a tremendous advantage for single side band radio, particularly in the crowded 3- to 30-megacycle high-frequency range where low power but long distance are the usual military requirements.

INTEREST and utilization in the 3- to 30-megacycle radio-frequency range by the military have been on the wane since World War II with the development of very high and ultrahigh-frequency radio and radar equipment.

However the distinct advantages of covering round-the-world distances which the HF range has over the VHF and UHF ranges and with less power than that required by the low-frequency range could not be overlooked by SAC in carrying out its worldwide strategic mission.

During the past decade, radio amateurs have been experimenting with single side band radio. Its theory of operation was known and experimented with some twenty-five years ago. But only during the past few years has its practical application been successful. Today the radio "hams" are either scrambling to "go to SSB" or stubbornly resisting its impact.

I have been experimenting with single side band radio under somewhat similar conditions and in geographical areas

that aircraft commanders would encounter.

Gen. Curtis E. LeMay, commander in chief of the Strategic Air Command, is a fully qualified and practicing radio amateur. Both of us now "work SSB."

Three times during 1956, I flew a Boeing transport C-97 plane furnished with SSB radio equipment, operating in the 3- to 30-megacycle frequency range, to test single side band in typical communications conditions. In the spring my crew and I made the air trip from Omaha to U. S. Air Force bases in Alaska and the Far East. A midsummer trip included stops in Alaska and Greenland and a flight over the North Pole. On a third trip in the fall of the year we flew to England, Germany, North Africa, and Greenland.

Whenever we were airborne on these trips, the SSB equipment was being worked. During the midsummer trip, the Offutt Air Force Base Military Affiliate Radio System (MARS) station monitored the transmissions from aircraft continuously using the same type of SSB equipment as that mounted in the aircraft. For only 1½ hours of time was the Offutt station unable to "read" the aircraft transmissions. Of particular interest on this trip was the radio contact made with the single side band radio station being run by personnel on duty with Operation Deep Freeze in the Antarctic. As many as 1,500 different radio stations were logged as contacts on this trip.

On all these flights a few well-known and experienced "hams" were invited to accompany us primarily to operate SSB equipment in the radio amateur frequencies included in the 3- to 30-megacycle frequency range. Their experience and expert advice given to SAC during and after these trips proved valuable in saving time and money in SSB radio development and use.

AS a result of these trips and further research, done for the most part by Art Collins, president of the Collins Radio Company, and his engineering staff, the commander in chief of SAC directed that a point-to-point SSB radio net be set up to augment and further enhance worldwide communications capabilities of the command.

"This transmission process concentrates the transmitted energy into the selected side band of the modulated radio frequency, suppressing the carrier and eliminating the other side band, resulting in a theoretical eightfold power increase."

By using some single side band equipment already on hand, supplemented with several quickly procured sets, in November 1956 the MARS stations in several key sites began full-time operation on a special SSB net. In most locations the MARS stations were best suited for temporarily housing the equipment as well as furnishing antennas, power, and operators. The program will be expanding during 1957 to provide a permanent arrangement for these features of the net.

Of particular interest is the type of antennas developed to maximize the radiation from the SSB one-kilowatt transmitters. For example, the Offutt Air Force Base installation has a triple billboard antenna array, each billboard composed of seventeen horizontally driven elements, using two feed points and two matrices per billboard tower. Each antenna tower has an associated horizontally polarized, curtain-type reflector, projecting a wide-angle directional beam lobe.

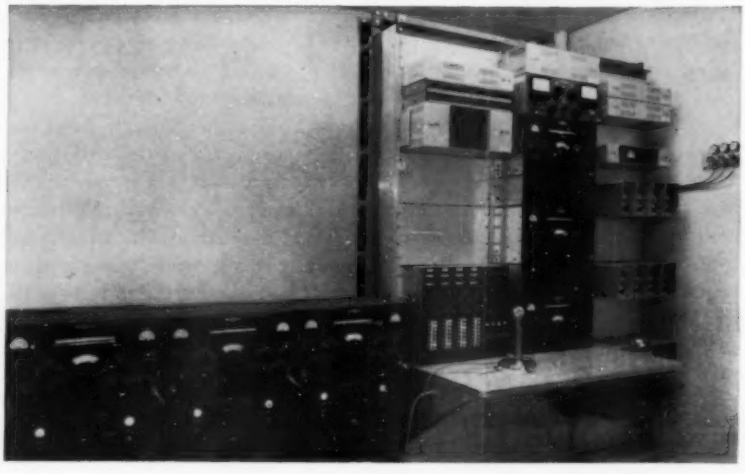
There are two features of the SSB radio net which improve its operational efficiency but are not attributable directly to SSB theory of operation. The first feature is tying in the local base telephone system and aircraft control "hot" long lines to the SSB radio position so that information received from any one source can be relayed directly to the users at any of the stations.

The other feature is the comparatively small size of the equipment and its relatively low power requirement, considering the geographical range possible when it is expertly tuned and operated. This advantage is militarily desirable since physical security and control are made easier by having the entire station within the confines of the air base.

The use of single side band radio equipment is being planned in the Air Force-wide MARS program. Here distance and fidelity are primary considerations for the type of traffic handled, while speed is secondary. However, SSB radio operations are of special interest to the MARS program. Combat aircraft wings rotate periodically to overseas locations on short temporary-duty tours. Such short tours often prevent adequate personal planning on the part of SAC families.

PERSONAL emergencies involving sickness and finances are often relieved by a few minutes conversation via a MARS radio contact. The SSB equipment now programmed will improve the prospects of getting communications through to the home bases of these airmen on overseas duty with the SAC rotational wings.

An SSB operating position at SAC headquarters, Offutt Air Force Base, Omaha, Nebr.



Defense Highlights: Monthly Review and Outlook

• **The International Geophysical Year,** which starts this July with the Vanguard satellite as its most spectacular project, has elicited growing interest in space flight.

For many years Dr. Wernher von Braun, director of research, Army Ballistic Missile Agency, has studied space travel and colorfully described the problems involved. Recently Maj. Gen. B. A. Schriever, Commander, Western Development Division, Air Research and Development Command, jumped further into the future. He predicted that several decades hence space battles will be the important ones.

"Our safety as a nation may depend on our achieving space superiority," he said. "We should be spending a certain fraction of our national resources to ensure that we do not lag in obtaining space supremacy."

As if in answer to that statement a recent survey shows that many American industries in the aëronautics, electronics, and computer fields were putting money into the multitudinous unsolved problems of space travel. In many cases the company space projects are closely related to their work on military missiles. As one company official said, "We don't expect to send any one to Mars in five years, but it's not too soon to get started commercially in the space field."

The most intriguing possibility in space-travel futures is the photon-propelled space ship presented in a theoretical study by Dr. Ernst Stuhlinger, chief of the Research Section, Guidance Control Branch, Redstone Arsenal. He talks lightly about 3.5 hours to the moon, 2 days to visit a planet. Much sooner we can expect a fifty per cent improvement in chemical propellants followed by close competition from nuclear-powered, ion-accelerating engines of great efficiency.

• **In the face of such fabulous possibilities** it is disheartening to learn of a Defense Department official's remark that the military should not be responsible for deciding the amount of emphasis to be placed on pure or applied science or engineering, except in their effect on military weapons development.

It is doubtful if a project to study the migration of earthworms would aid defense problems, but most of the quantum jumps in weapons development have stemmed from scientific discoveries that originally seemed to have no useful application. It would be tragic for the military to return to the dark ages of 1940-1941 when they were so out of touch with research that scientists such as Bush and Fermi had to fight hard to persuade the armed forces to undertake development of a nuclear fission bomb.

• **Industry** is now being blamed for inadequate materials research. A spokesman for the Air Research and Development Command says "the standard rate of effort in materials research and development has not been able to keep pace with the need . . . A serious industrial impasse could result unless timely solutions can be found."

Rear Adm. Hyman G. Rickover, who is in charge of naval reactors for the Atomic Energy Commission, made stronger statements. He pointed out that material and equipment used in conventional power plants must meet exacting standards when adapted for use in nuclear plants. He said "we (AEC) found that industry frequently has inadequate understanding of the fundamentals involved in straightforward applications" and claimed that industry had caused considerable delay in nuclear power developments through unexpected and unexplainable flaws and failures.

It appears that there may have been some loopholes in basic research in the national failure to discover flawless materials and methods before we knew we would need them.

• **Our National Guard** has risen again to the Nation's need, not to a direct call to arms but to a call to increase their combat readiness and effectiveness. In this critical era greater skills are required of the first echelon of our citizen armies. The tempo of modern war leaves less time for final training yet requires greater knowledge to use the new weapons and to survive under present battle conditions.

The Guard has agreed to a six-month active-training period to be incorporated into its program in an orderly manner, although they shall have to make greater efforts in recruiting. The first effort was most successful when, in spite of the increase from 11 weeks to 6 months of training, the Army National Guard enlisted over 4,400 new members and the Air National Guard 600 members. Many others signed up who had prior service, and some took advantage of the last few months in which they could join under the old regulation requiring only eleven weeks of training.

• **A fleet of jet-powered seaplane bombers** is urged by a committee of scientists and aircraft production experts. The committee was established by Dr. C. C. Furnas, formerly Assistant Defense Secretary for the now defunct Research and Development Office. The committee recommended that nuclear-powered water-based aircraft be developed in tests looking toward making them part of the weapons systems of the military forces.

By introducing water-based nuclear aircraft the armed services could save money by not having to develop land bases and expensive runways while putting early models of nuclear craft through tests, the advocates of the program said.

For strategic purposes, such planes would have the advantage of a mobile, continuously dispersed weapons system, randomly located and independent of fixed bases. Most important, the report said, potential enemies would find it nec-

essary to build large-scale and costly additional perimeter defenses.

• **The Hawk surface-to-air missile** now under final test at White Sands Proving Ground is designed for defense against low-flying enemy aircraft. Antiaircraft artillery and the Nike family of missiles are primarily for use against high-altitude attacks. At present machine guns are the principal weapons available to combat low-level attacks, but they suffer from limited range. Hawk is planned to fit into the Nike system to plug the weakness that has been found in the low-altitude area.

• **The Navy** and Glenn L. Martin Aircraft Company are pushing work confidently on the third P6M flying boat. They have ordered much of the production tooling in spite of the two earlier crashes which were caused by faulty control systems rather than structural weaknesses.

While waiting for the next P6M prototype, tests are being conducted with P5M's to demonstrate the use of an LSD (landing ship, dock) as a seaborne base. By ballasting down the landing craft one large flying boat can be accommodated for repairs, thus implementing the strategic concept of movable water bases for heavy bombers.

• **The Department of Defense** is going all out to commemorate Armed Forces Day on Saturday, May 18th, with the theme—"Power for Peace." Comprehensive and impressive ceremonies and displays are planned at all military activities in coöperation with civic leadership. Details on local events can be obtained at your near-by military headquarters or branch office.

• **The Navy** reveals only now that another gap in the early-warning net of the Continental Air Defense Command was closed in July 1956. The sea area off our northeast coast has been covered by the Atlantic Barrier Command in an extension of the land-based radar DEW line, mid-Canada, and Pine Tree lines.

The Barrier Command is comprised of three Navy airborne early warning (AEW) squadrons using Lockheed WV2's and two squadrons of picket destroyers. A round-the-clock vigil is maintained in generally adverse weather conditions. The number of aircraft and ships on station at one time cannot be disclosed, but it is believed the operation covers an arc that approaches closely to the British Isles.

"Military Literature," a reading guide to authoritative texts on the Army, Navy, and Air Force of the United States, is available as a reprint from A.O.A. Headquarters, Mills Building, Washington 6, D. C.

This leaflet contains the articles that appeared recently in successive issues of ORDNANCE *magazine as follows: "Air Power Literature," by Brig. Gen. Dale O. Smith, U.S.A.F.; "Bibliography of Sea Power," by Rear Adm. E. M. Eller; and "Our Military History," by Brig. Gen. P. M. Robinett.*

• **Another little-noticed but effective adjunct** to the country's perimeter defense at sea are the squadrons of semirigid lighter-than-air craft (LTA). Although vulnerable to air attack they carry prodigious amounts of search and attack equipment for antisubmarine work or long-range early warning. The LTA has proved its capability in long endurance flights in extremely foul weather.

• **The results** of British Defense Minister Duncan Sandys' visit to this country are coming to light. A British team of missile experts has been touring United States installations, and agreement was reached at the Bermuda Conference that we would provide Great Britain with intermediate-range guided missiles, without warheads, "in the interest of mutual defense and mutual economy."

A quick look at the status of IRBM development indicates that it would take about five years before we could produce enough "Thor-Jupiters," or what have you, to supply ourselves and the British with ballistic missiles. In the interim our winged missiles Snark or Navaho would be very handy to have in the NATO defense locker.

• **The Army is reorganizing** its units across the board and will be made up of newly constituted Infantry, Armored, and Airborne divisions.

The Infantry division will contain five administratively self-contained battle groups. Each battle group is provided an assault 90-mm. self-propelled gun platoon, light reconnaissance tanks, armored personnel carriers, and mortars up to 105-mm., as well as streamlined rifle companies.

A tank battalion is attached to a division but so organized that small tank units can be attached to each battle group as required.

A reconnaissance battalion and signal unit will be enlarged over such current units that serve the division. For division logistical support in addition to the usual elements there will be an aviation company and a transportation battalion. The transportation battalion, a new concept, incorporates sufficient personnel-carrier capacity to lift one battle group for swift movement.

The aviation company will provide aircraft for the reconnaissance battalion, spotting for the division artillery, and tactical emergency airlift for medical evacuation, combat resupply, and patrol operations.

While the division strength has been reduced by 3,700 men, the infantry elements which engage the enemy directly have been increased by 450 through the increased squad strength in the combat groups.

The Armored division will have a strength of 14,617, a slight reduction, but will have increased aircraft target acquisition capability, increased strength of its signal unit, and an Honest John rocket battery.

The Airborne division will be completely air-transportable and will also be based on the 5-combat-group structure. As in the other two types of divisions, reconnaissance communications and logistic support will be increased in spite of the reductions in personnel by utilization of the most modern equipment.

Nuclear Ordnance Progress

An Editorial

PROGRESS of ordnance on all sides is reassuring to all advocates of a strong defense. This progress is apparent in the fields of conventional as well as unconventional weapons. The latest report of the Atomic Energy Commission furnishes some strong corroborative evidence. This is the twenty-first semiannual report and reflects the skills as well as the management of the program since its inception.

The report emphasizes, first, that research and development activities designed to increase and improve the United States arsenal of weapons continues. Included in these areas were further investigations of designs for defensive use and of methods of reducing radioactive contamination resulting from weapons detonations. The Commission completed an operation known as Redwing. This involved a series of tests following which no radiological hazards to populated areas would have resulted.

On the production side, the Commission discloses little more than that the arsenal of nuclear ordnance was widened in variety. Increased facilities for accelerated research developments and production programs of nuclear ordnance called for "certain expansions of the weapons research, engineering, and production complex."

IN general, these expansions are in the form of modifications and additions to existing facilities such as at the Radiation Laboratory of California Institute of Technology, Livermore, Calif. In New Mexico, the Sandia Corporation, a subsidiary of Western Electric Company, will undertake ordnance engineering in support of the Radiation Laboratory programs. The expansion of the production plant at Rocky Flats, near Denver, Colo., has proceeded satisfactorily. The Iowa Ordnance Plant at Burlington, Iowa, and the Pantex Ordnance Plant near Amarillo, Tex., are about to expand their facilities.

So also in the areas of ballistic and other tests. A special testing area in southern Nevada, within the U. S. Air Force Nevada Gunnery Range, is being prepared. A new range is being installed for determining the ballistic characteristics of inert weapon shapes dropped from aircraft.

And the following additional expansions are under way or scheduled for early initiation: at the Los Alamos Scientific Laboratory, Los Alamos, New Mex., operated by the University of California; at the AEC's Kansas City plant operated by Bendix Aviation Corporation; at the Commission's Sandia Laboratory at Albuquerque, operated by the Sandia Corporation; and at the Commission's South Albuquerque Works operated by ACF Industries, Inc.

Notable progress also was made in weapons testing. Operation Redwing was concluded in July 1956. This test, conducted at Eniwetok Proving Ground, in the Pacific, resulted in impressive information relating to means of reducing radioactive fallout from weapons firing. New design principles will result, and these will lead to more efficient weapons that can be employed more effectively.

These are phases of the Commission's operations which relate specifically to ordnance and armament. The report reveals in great detail the nonmilitary activities, both national and international, which portend such vast changes in so many ways for individuals as well as nations. We leave to others more skilled in the efficacy of these undertakings the appraisal of their ultimate value and their ultimate political significance.

To return to the nuclear ordnance topic, it must be admitted that the possible use of nuclear agents in battle is bringing to armament a power which until now has seemed almost uncontrollable in its military effect. But gradually the counsels of wise minds are being heeded, and the application of nuclear energy to smaller controllable uses is receiving more general emphasis.

In this the evolution of nuclear ordnance is following the pattern which has applied throughout history. Practically every conventional type of weapon in its beginning was unconventional. Meticulous test and application, fortified by the study and development of strategy and tactics, finally brought each agent into the realm of conventional use. So in the course of time it probably will be with nuclear ordnance.

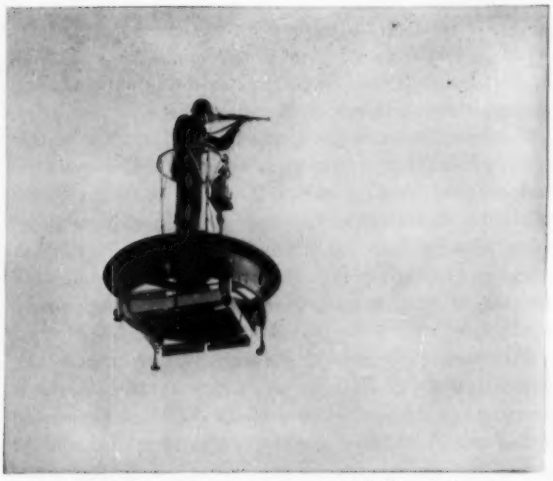
The report of the Commission, guarded though it is, seems to indicate that after 10½ years the area of the "big bang" is beginning to be supplemented by the area when military targets can be reached with accuracy and precision. This is a stimulating development which has far-flung impacts morally as well as physically. And the more the unmoral side of unlimited war is stressed the better it will be for mankind!

Speaking of the moral aspects of nuclear energy recalls the words of Thomas E. Murray, distinguished member of the Atomic Energy Commission. He has labeled the relationship between morality and security as "the forgotten equation." In elaboration of his philosophy, he said:

"THIS equation is inherent in the Western tradition. The first security that a civilized nation must protect is the security of its own moral life. The nation is secure in proportion to its fidelity to the moral norms that form the spiritual substance of the national life. Concretely, if the United States is obliged to have recourse to armed force in its own defense, it must understand that it is committed to a moral use of force, on penalty of self-destruction—I mean the destruction of its moral self.

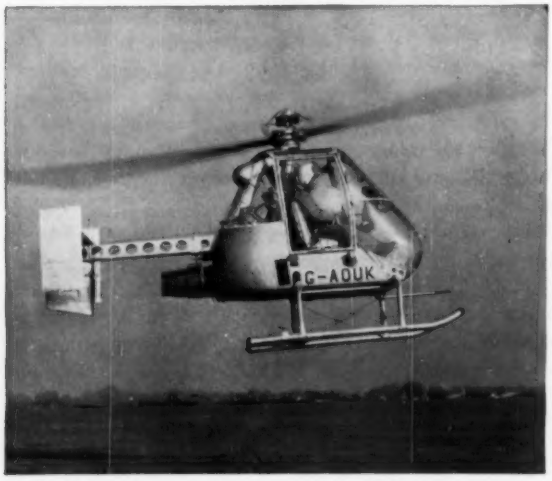
"The security which America seeks cannot be simply physical. It must also mean the protection of the spiritual identity of America as a member of the family of civilized nations. If America were to lose its own soul by sins of unjust violence, it matters little what else it might gain."

New Shapes in the Sky



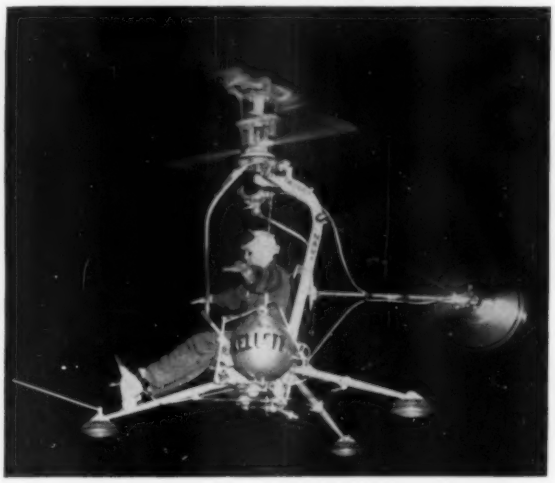
The Army's Flying Platform, above, by Hiller Helicopters, uses multiengined ducted fans to transport an infantryman and his weapon. Much larger platforms are envisioned.

Above is the first released photograph of the Air Force F-105 Thunderchief supersonic jet fighter now undergoing flight tests at Republic Aviation Corporation.



The Fairey Ultra-Light jet-powered helicopter, above, is being evaluated by the U. S. Defense Department. The Bell turbopowered XH-40, below, will cruise at 100 m.p.h.

The Fairchild C-123 Provider assault transport, above, also can drop men and equipment by parachute. Below is the stable Kellett one-man rocket-powered helicopter.



ASSOCIATION AFFAIRS

Small Arms Division Holds Meeting at Air Force Armament Center, Florida

The annual classified meeting of the A.O.A. Small Arms and Small Arms Ammunition Division was held at the Air Force Armament Center, Eglin Air Force Base, Fla., on February 6-7, 1957, with Maxwell R. Warden, chairman of this Division, presiding. Forty-one members of the Division were in attendance, together with fifteen other members of the Association, including Henry N. Marsh, general chairman, Technical Divisions and Committees, who represented national A.O.A. headquarters.

The technical session of the meeting opened at 9:30 a.m. on February 6th with a welcoming address by Maj. Gen. Edward P. Mechling, U.S.A.F., commander of the Air Force Armament Center.

Following the welcoming and other introductory remarks, the meeting was taken over by Maxwell Warden, president, Remington Arms Company, chairman of this Division.

The following technical papers were presented during the day's session:

"Small Arms Steel Cartridge Case Development," by Dr. Philip H. Burdett, Remington Arms Company, chairman, Steel Cartridge Case Committee.

"U. S. Small Arms Ammunition Manufacture in Foreign Countries," by Col. George A. Miller, Jr., Frankford Arsenal, Consultant, Small Arms Ammunition Committee.

"Development and Production Status of Ground Small Arms Weapons," by Herman F. Hawthorne, Springfield Armory.

"Status of the Rifle Program," by Dr. F. H. Carten, Office, Chief of Army Ordnance.

"Development and Production Status of Aircraft Weapons," by O. H. von Lossnitzer, Springfield Armory.

"U.S.A.F. Aircraft Gun and Ammunition Program," by Lieut. Col. Jan M. Laitos, U.S.A.F., chief, Air Munitions Development Laboratory, Air Force Armament Center.

"Aircraft Gun Propellant and Explosives Development," by Dr. David C. Sayles, Air Munitions Development Laboratory, Air Force Armament Center.

"Current and Anticipated Problem Areas Created by Improvements in Aircraft and Weapon Capabilities," by Lieut. H. C. McClammy, Air Munitions Development Laboratory, Air Force Armament Center.

"Test Capability and Procedures of the Air Force Armament Center," Part I by Maj. B. F. Hardaway, Jr.; Part II by Robert L. Reeder, directorate of Munitions Testing, Air Force Armament Center.

The second day was devoted to a personally conducted tour of the Air Force Armament Center. This tour included the exhibition of recent aircraft gun developments, the laboratories of the Directorate of Airborne Systems, the Climatic Laboratories, the witnessing of firing demonstrations of aircraft guns and installations, and an inspection of the flight line in the Heavy Systems Building.

Members of the A.O.A. Small Arms and Small Arms Ammunition Division who attended annual meeting of the Division at the Air Force Armament Center.

On the evening of the second day there was a joint dinner meeting attended by 118 members of the Florida Post of the American Ordnance Association. Col. E. A. Romig, U.S.A.F., president of the Florida Post, as master of ceremonies introduced the distinguished guests present including Maj. Gen. E. P. Mechling, who thereafter acted as toastmaster.

General Mechling called on Col. Henry Marsh for a few remarks, including the reading of the preamble to the constitution of the A.O.A. General Mechling then called upon Maxwell Warden to introduce the principal speaker of the evening, Maj. Gen. J. H. Hinrichs, Deputy Chief of Ordnance, United States Army.

General Hinrichs gave a very interesting and informative talk on the subject, "The Ordnance Corps and the Small Arms Industry in the Atomic Era." He stressed the vital importance of small arms, stating that the soldier on the ground equipped with the most efficient hand weapons is as necessary in the Atomic Age as he ever was. As a consequence, General Hinrichs continued, "This presents a challenge to the small-arms industry of our country to assist our armed forces, in every way possible, in developing the most efficient weapons in small arms for our United States soldier."

Small Arms Steel Case Ammunition Committee Meets at Frankford Arsenal, Pa.

The eleventh meeting of the Small Arms Steel Case Ammunition Committee of the A.O.A. Small Arms and Small Arms Ammunition Division, was held at Frankford Arsenal, Philadelphia, Pa., on January 17, 1957, at the invitation of Brig. Gen. J. M. Colby, commanding general.

Dr. Philip H. Burdett, Remington Arms Company, Bridgeport, Conn., chairman of the Committee, presided. In attendance were fourteen regular members of the Committee, six consultants from the armed services, and twenty-two engineers of the staff at Frankford Arsenal.

General Colby, in his greetings to the Committee, cited examples of the continued requirement for reliable small arms and ammunition and the need for contin-

ued development. Other Ordnance representatives summarized the present status of the small-arms steel program, and industry representatives reported on their individual programs.

In general, progress is encouraging, particularly in the calibers of principal Ordnance interest—caliber .30, caliber 7.62 mm. NATO, and 20 mm. (60/20). Ways gradually are being found for utilizing less specialized grades of steel, and organic finishes are being approved as alternates to the chromated zinc finishes previously specified. Equipment for heat-treating remains a problem, and simplified heat-treating methods and processes eliminating heat treatment are under continued development.

This Committee meeting was undoubtedly the most interesting and informative technical session ever held by this important Committee of the Small Arms and Small Arms Ammunition Division. It clearly indicates the great interest on the part of both the armed services and American industry in the continued energetic development of steel cases for small-arms ammunition.

General Westphalinger Speaks before Special Meeting of Frontier Chapter

Maj. Gen. H. R. Westphalinger, director of procurement for the Deputy Chief of Staff for Logistics, Department of the Army, was the guest of honor and principal speaker at a special meeting of the Frontier Chapter of the Empire Post at Buffalo, N. Y., on February 27th.

The meeting was called to order at the Buffalo Club to renew the interest of the local A.O.A. members in Ordnance Association affairs.

Ira G. Ross, director, Cornell Aëronautical Laboratory, Inc., left, inspects model of the Army's Lacrosse missile with Maj. Gen. H. R. Westphalinger, Army procurement director, and Col. W. A. Davis, deputy chief, Rochester Ordnance District.

Prior to the meeting General Westphalinger and Col. William A. Davis, deputy chief of the Rochester Ordnance District, were treated to an inspection of the Cornell Aëronautical Laboratories where the new Army Ordnance missile, Lacrosse was developed.

At the dinner John J. O'Neil, Chapter chairman, presided and after welcoming the 130 members and guests called on Ralph F. Peo, Empire Post president and head of Houdaille Industries, Inc., to introduce General Westphalinger. The general spoke on new inventions, techniques, and developments. He described the many new areas of research and development that are being investigated by Army Ordnance in its tireless search for new weapons. He made particular comment on the able support that the Army had received from the Cornell Laboratories in developing the Lacrosse missile.

At the close of the meeting Mr. Peo thanked the members for their attendance and exhorted them to continue to broaden the circle of membership in the A.O.A.

Others seated at the head table were: Dr. C. C. Furnas, chancellor, University of Buffalo; Ira C. Ross, director, Cornell Aëronautical Laboratory; Ray P. Whitman, vice-president, Bell Aircraft Corporation; Daniel Murphy, Symington-Gould Corporation; Max Scott, director of research, Sylvania Electric Products Corporation; Col. Alexander S. Young, commanding officer, Rochester Aircraft Procurement District; Capt. O. H. Cote, Navy Bureau of Aëronautics representative, Buffalo, N. Y.; Col. W. A. Davis, deputy chief, Rochester Ordnance District, and secretary-treasurer of the Empire Post.

Southern Tier Chapter of Empire Post Elects Officers at Elmira, N. Y., Meeting

The reactivation meeting of the Southern Tier Chapter of the Empire Post was held in Elmira, N. Y., on Thursday, March 14th. The Chapter opened to a new page in its career with the election of officers under the temporary chairmanship of Claude G. Wright, vice-president of the Empire Post.

The following were unanimously elected: Chairman, Col. Walter R. Slotzhauer, Ordnance Corps, U.S.A., Ret., Ithaca, N. Y.; vice-chairman, Michael J. Lawlor, Ordnance Corps, Ret., Page Airways, Inc., Rochester, N. Y.; and secretary-treasurer, Charles A. Emerich, Ward LaFrance Truck Corporation, Elmira.

The principal speaker was Col. W. A. Davis, deputy chief of the Rochester Ordnance District. Colonel Davis described the Army's plans for its new "Pentomic divisions." In an illustrated talk he pointed out a typical battle deployment of a Pentomic division and showed how this new divisional organization with the tremendous increase in firepower of the Army's new weapons would enable it to defend a 100-mile front, 100 to 300 miles deep, with only 10,000 men. In World War II a division was expected to protect a 10-mile front with 10 miles of support depth.

The colonel pictured an atomic battle of the future as follows: "As the enemy moves forward following his atomic strikes, he is subjected progressive'y to increasing frontal and flanking attacks by highly mobile battle groups which move out to meet and destroy him. Flexibility and rolling with the punch, rather than rigidity, will be the keynote of the defense."

Distinguished guests at the speakers' table included: Col. A. S. Young, chief, Rochester Air Procurement Office; Rear Adm. Ralph Roberts, U.S.N., Ret.; Comdr. Stanley Caplan, inspector of naval material, Buffalo.

The rejuvenation of this Chapter was due principally to the devoted efforts of "Mike" Lawlor who was also the dinner chairman. The members of the Southern Tier Chapter are firmly resolved to continue the activity they have started so successfully and are planning another meeting in the late spring.

General Medaris Is Guest of Honor at Meeting of Lone Star Post, Dallas

At Dallas the Lone Star Post members assembled at the sparkling new Riverlake Country Club on Monday, February 18th, for golf and dinner to honor Maj. Gen. J. B. Medaris, Commanding General of the Army Ballistic Missile Agency, Huntsville, Ala.

In the afternoon, in spite of a drizzle, many foursomes teed off after General Medaris. The general was a member of the "unification foursome" with Col. J. E. Corey (U.S.M.C.), Captain Richards (U.S.N.), and Lieut. Col. Joseph Earll (U.S.A.F.).

R. C. Blaylock, Post president and a vice-president of Chance Vought Aircraft, Inc., presided at the dinner meeting of over 200 members and guests. The invocation was delivered by Rev. Sterling Webster, vice-president, Southern Methodist University. After introducing the guests at the head table, Mr. Blaylock called on A. B. Thompson, Post secretary, to read the preamble of the A.O.A. constitution.

I. Nevin Palley, vice-president, Temco Aircraft Company, was presented with a certificate of appreciation for his leadership as Post president in 1955-1956. Capt. J. M. P. Wright from A.O.A. headquarters delivered the tribute.

The afternoon golfers were recognized for their outstanding performances and willingness to defy the elements. Many cups and prizes were handed out by E. Doak Walker, president of the Riverlake Club. The handsome cup for low net was won by Colonel Corey. J. N. Day of Murray Company of Texas, Inc., assisted by Col. H. R. Jordan then conducted a ceremony in which General Medaris was presented with letters of citizenship to the City of Dallas and the State of Texas.

General Medaris in his speech outlined the management procedures and policies that govern the missile development work at his command. He noted that industry is brought into programs early so that it will be prepared to take over production promptly. The audience was impressed by the general's statement that his missile agency was able to schedule the experiment and research work and to meet the schedules. He said the necessary "K factor" was evolved from historical study of previous developmental efforts.

At the head table, not mentioned previously, were: L. A. Childs, Jr., and R. H. Norris, Post vice-presidents; F. B. McKimball, a director of the Post; Col. W. A. Evans, deputy chief of the St. Louis Ordnance District; and Cadet Clyde E. Beal, Jr., chairman of the A. & M. College of Texas Chapter.

Brig. Gen. Richard H. Somers Long Was Association Stalwart

Brig. Gen. Richard H. Somers, distinguished Army Ordnance officer and twice secretary-editor of the Ordnance Association, died at Pitman, N. J., on January 22, 1957.

He was the second editor of this journal, 1922-1925, and was instrumental in bringing it to its present recognized status as a leader in the military-industrial field. For his service he was awarded the Association's Crowell Gold Medal in 1946.

General Somers was born in New Jersey and was appointed to the United States Military Academy from that State in 1903. Upon his graduation from West Point in 1907 he was commissioned a second lieutenant of Coast Artillery. He began his Army Ordnance service in 1909 at the Sandy Hook Proving Ground and later was assistant professor of ordnance and gunnery at the United States Military Academy.

When the Aberdeen Proving Ground was begun during the First World War he was one of the first officers of its staff and served as commandant of the Ordnance School there. Throughout his long active military service in the Ordnance Department he served as chief of the Artillery Division, Office of the Chief of Ordnance; Ordnance Officer of the Panama Canal Department; commanding officer of the Watervliet Arsenal; and chief of the Ordnance Technical Staff.

General Somers also served as executive officer of the Army Industrial College following his graduation from that institution in 1924. He was a graduate of the Ordnance School of Technology and the Graduate School of Business Administration, Harvard University. He served also as assistant professor of military science and tactics at the Massachusetts Institute of Technology.

General Somers first came to the Ordnance Association in the days when the office of secretary-editor was filled by a Regular officer of the Ordnance Department on active duty. He succeeded the late Col. James L. Walsh as secretary-editor of the Association in 1922. He returned again to the Association after his retirement from active service in 1942 and served the society and its publications until 1945. Thereafter, he became professor of mathematics at Dartmouth College and subsequently retired to his native New Jersey.

General Somers was a man of exceptional talent and industry. Throughout his career as an Ordnance officer he was known as one of the Department's best mathematicians, sharing honors with his coworkers, the late Maj. Gens. William Crozier and William H. Tschappat, both of whom contributed to the Department's well-earned fame as a leading engineering and scientific organization.

Although he filled many important Ordnance posts, probably none brought him greater pleasure and satisfaction than

Brig. Gen. Richard H. Somers

his part in the establishment of the Aberdeen Proving Ground at the beginning of the First World War, and his service in the formative years in the Army Industrial College.

The former has merited the distinction of the world's best-known armament proving center and the latter, now the Industrial College of the Armed Forces, is firmly established as an integral part of our military educational system at the highest level.

During General Somers' régime the Ordnance Association was known as the Army Ordnance Association to which he contributed in an exceptional way. This journal was the recipient of his best guidance and under his direction became known the world over as an authoritative reference work for engineers, industrialists, and military personnel.

Equally lasting in the Association's progress was General Somer's guidance of the Ordnance Endowment Fund during his second tenure as secretary. The Fund had been established prior to our country's entrance into the Second World War and was partially completed when the war started. He assisted in continuing the growth of the Fund which today, in the hands of a trustee, gives the Association some assurance that its work will continue into the future when public in-

terest in armament preparedness may again subside.

General Somers, his life and work, hold special place in the annals of the Association as they do in the achievements of the Ordnance Corps and of the Army. Likewise, his memory and the affection in which he is held by his friends and admirers in the Association will be revered. —L. A. C.

Gen. Lucius D. Clay Is Guest of Honor at the St. Louis Post Meeting

Gen. Lucius D. Clay, board chairman, Continental Can Company, and former head of the United States Forces in Europe, was the guest of honor and principal speaker at the annual meeting of the St. Louis Post, A.O.A., March 7, 1957. The presiding officer was Maj. Gen. L. J. Sverdrup, president of the Post, and president of Sverdrup & Parcel, Inc., St. Louis. More than 600 members and guests were present.

General Clay, under whom the brilliant airlift wrought such basic changes in the European defense problem, urged a strong national defense as the only sure deterrent to war. He referred to it as "a major tool in the accomplishment of our foreign-policy objectives." He spoke at length on the worldwide military and diplomatic responsibilities of the United States and expressed the hope that diplomatic efforts might serve to make a solution possible without war.

"Perhaps diplomacy," he said, "can once again cure the chronic causes of trouble in the Middle East. Our progress has been real and we must be patient. Only the strong can afford to be patient."

General Sverdrup, retiring as president of the Post, brought to a conclusion a most successful tenure in that office. Under his direction the Post continued its lengthy record in emphasizing throughout that important industrial area the continuing need for scientific and industrial preparedness to meet the armament requirements of our fighting forces. He is well known for his outstanding service on the staff of General MacArthur in the Pacific during World War II who valued his active participation in military affairs as one of the foremost Reserve officers in the country.

At an election held at the meeting the following officers were elected: George W. Brown, vice-president of Wagner Electric Corporation, was named Post president. Other Post officers elected were: A. J. Mummert, vice-president; Thomas L. Waters, secretary; Howard Goebel, treasurer. Directors elected were: General Sverdrup, F. S. Elfred, W. A. Morse, W. P. Gatley, Edwin P. Meissner, Jr., and Warren Drake.

Other speakers at the meeting were Brig. Gen. Jean E. Engler, chief of the Industrial Division, Office of the Chief of Army Ordnance, and Col. Leo A. Codd, executive vice-president of the A.O.A.

Proof Shop is Scene of Midwinter Meeting of Aberdeen Post of A.O.A

The Aberdeen Post made history on February 28, 1957, when it held its midwinter meeting in the Proof Shop of the Proving Ground. The scene was laid in the midst of tanks, artillery, gun barrels, vehicles, and howitzers in Building 525. In spite of unpleasant weather this unusual setting drew a lively crowd of over 160 members.

After an invocation by Proving Ground Chaplain Maj. Harvey M. Hardin, Col. E. B. Cummins, Post president, introduced Maj. Gen. C. H. Deitrick, commanding general, Aberdeen Proving Ground, who welcomed the members to the establishment. Colonel Cummins then read the preamble to the A.O.A. constitution and called on Capt. J. M. P. Wright, U.S.N., Ret., of National headquarters to make a special presentation. This was the award of an inscribed A.O.A. plaque to Thurman F. Naylor, past president of the Aberdeen Post.

The guest speaker, Russell C. Walters, assistant engineer in charge of Glenn L. Martin Company's Project Vanguard, described in interesting detail the developmental progress of the world's first artificial satellite. With the aid of charts and film Mr. Walters outlined the operation of the three stages of the satellite's propulsion and the predicted trajectory that Vanguard will follow in attaining its orbit.

It is expected that this 20-pound vehicle will be in orbit around the earth for up to one year. It was interesting to discover that several sets of the satellite and its propulsion units are being prepared, although the speaker would not say if more than one would be launched eventually.

Also at the speakers' table were: Col. T. R. McDonald, assistant commandant of the Proving Ground and the second vice-president of the Post, and Maj. J. R. Black, Jr., Post treasurer.

At head table at Aberdeen Post meeting were, left to right: T. F. Naylor, past president; Col. T. R. McDonald, deputy commander of Aberdeen; Russell Walters, Glenn Martin Company, guest speaker; E. B. Cummins, Post president; Maj. Gen. C. H. Deitrick, commanding general of Aberdeen; Capt. J. M. P. Wright, A.O.A. staff headquarters; Maj. J. R. Black, Jr., Post treasurer; Maj. H. M. Hardin, chaplain.

Florida Post Holds Open House and Election of Officers at Eglin AFB

The Florida Post held its annual open-house meeting and election of officers at the Eglin Air Force Base Officers' Club on Monday, January 14th. Lieut. Col. Henry B. Kucheman, Jr., Post president, presided at this congenial gathering.

The nominating committee's recommendations were unanimously accepted. The following new officers, all members of the Armament Center, were installed in the closing ceremony of the meeting:

President, Col. Eugene A. Romig, vice commander of the Air Force Armament Center; First vice-president, Lieut. Col. Marvin E. Kay; Second vice-president, M. Sgt. Michael E. Cassese; Secretary, Robert L. Reeder; and Treasurer, Dr. Alan S. Galbraith.

Maj. Gen. Edward P. Mechling, commander of the Air Force Armament Center, remains the Florida Post's representative on the Association's Council.

Texas A. & M. College Inaugurates Student Chapter of Lone Star Post

The Agricultural and Mechanical College of Texas at College Station, Tex., inaugurated a student Chapter on February 19th under the auspices of the Lone Star Post.

Over eighty students under the leadership of the Chapter chairman, Cadet Clyde E. Beal, Jr., assembled to formalize the establishment of their Chapter. Mr. Beal conducted a short business session and invited Capt. J. M. P. Wright from A.O.A. headquarters to introduce the guest of honor, Maj. Gen. J. B. Medaris, Commanding General, Army Ballistic Missile Agency.

Maj. Gen. J. B. Medaris, commanding general of the Army Ballistic Missile Agency, left, chats with R. C. Blaylock, Lone Star Post president, during meeting.

General Medaris described the aims and purposes of the A.O.A. and spoke of the many ways in which the Association is useful to the armed forces. He explained the vast requirements for engineers and scientists and congratulated the cadets for their interest in Ordnance.

Also at the meeting were many members of the staff and faculty including Col. J. E. Davis, commandant of cadets; Capt. Asa A. Hord, senior ordnance instructor; A. R. Kahan, director of the Texas A. & M. Research Foundation and a director of the Lone Star Post; and Col. H. R. Jordan, national Council representative of the Post.

After the meeting the general reviewed the Texas A. & M. Corps of cadets at a formal retreat and march-in to the dining halls. Dinner with the cadet regimental staff was followed by a postprandial coffee hour with cadet members of the A.O.A. Chapter.

Officers of the new chapter under Cadet Beal are Cadet Newton T. Harris, III, vice-chairman; Cadet T. E. Reddin, secretary-treasurer; and Cadet J. N. McCrary, public information officer.

Cumberland Valley Chapter Holds Inaugural Meeting at Letterkenny

The Letterkenny Officers' Club, Letterkenny Ordnance Depot, Chambersburg, Pa., was the scene of the festive inaugural meeting of the Cumberland Valley Chapter of the Philadelphia Post on Thursday, January 31st. Over seventy-five members were present to witness the formal inauguration of their Chapter, the latest edition to the expanding organization of the Association.

William H. Strauss, director of the Waynesboro Manufacturers Association and chairman of the meeting, called on the Rev. Benjamin V. Lavey, rector of the Trinity Episcopal Church of Chambersburg, for the invocation.

After coffee was served Mr. Strauss introduced the guests and called on Brig. Gen. R. W. Daniels of the Chambersburg Engineering Company to report the action of his nominating committee. General Daniels presented the following slate which was unanimously approved by the membership: President, Mr. Strauss; Vice-presidents, Col. Frederick G. Waite, commanding officer, Letterkenny Ordnance Depot, and Eugene C. Clarke, Jr., Chambersburg Engineering Company; Secretary, Albert P. Schwarz, Letterkenny Ordnance Depot; Treasurer, George J. Marshall, Letterkenny Ordnance Depot.

Present at Cumberland Valley inaugural were, left to right: Brig. Gen. R. W. Daniels, chairman, nominating committee; Brig. Gen. W. K. Ghormley, guest of honor; W. H. Strauss, Chapter president; Col. F. G. Waite, commanding officer, Letterkenny Ordnance Depot; Brig. Gen. E. C. Doleman, deputy commandant, Army War College; Rev. B. V. Lavey, Trinity Episcopal Church; E. C. Clarke, Jr., vice-president.

Mr. Strauss relayed a message from Everett B. Webster, president of the Philadelphia Post, who expressed his regrets at being unable to attend the meeting and welcome the new Chapter. Mr. Strauss paid special tribute to Colonel Waite for his generous support in helping to form the Chapter and in offering the facilities of Letterkenny.

A brief commentary on Association affairs was given by Capt. J. M. P. Wright from national headquarters, and on behalf of the national officers and directors he presented the charter of the Cumberland Valley Chapter to Mr. Strauss.

The guest of honor and principal speaker, Brig. Gen. William K. Ghormley, Office of the Assistant Secretary of Defense (Supply and Logistics) delivered a glowing report on the armed services' appreciation of the fine work done by the Ordnance Association. He then gave an extremely interesting exposition of the

background formulation and review procedure involved in the Armed Forces Procurement Regulations.

Of particular interest to the industry members present was the general's explanation of the numerous channels both in the Government and in industry through which the procurement regulations are kept realistic. He closed his address by wishing the new Chapter great success and expressed the hope that it would soon grow into an independent Post.

The Army War College at Carlisle, Pa., was represented by Brig. Gen. E. C. Doleman who is deputy commandant, and Comdr. L. D. Rucker represented the Navy's Ordnance Stock Office, Naval Supply Center, located at Mechanicsburg, Pa.

Instrument Precision Ball Bearing Committee Meets in New York City

The spring meeting of the Instrument Precision Ball Bearing Committee, Fire Control Instrument Division, American Ordnance Association, met at the Engineers' Club, New York City, on February 14, 1957. Owing to the illness of F. E. Ericson, chairman of the Committee, T. E. Rounds, Committee secretary, acted as the temporary chairman of the meeting.

After the opening preliminaries, Mr. Rounds introduced Brig. Gen. Burton O. Lewis, A.O.A. staff consultant for Technical Divisions and Committees, who expressed his sincere appreciation of Mr. Ericson's outstanding work on this Committee. General Lewis then presented a Certificate of Appreciation which had been prepared for Mr. F. Leister, of the Fafnir Bearing Company, in appreciation of his excellent work as chairman of the Subcommittee on Technical Standardization. In the absence of Mr. Leister, who was in Florida, the certificate was accepted by Mr. Hannan of his company.

Ralph L. Goetzenberger, chairman of the Fire Control Instrument Division, briefly described the aims of the A.O.A., emphasizing the importance of the Instrument Precision Ball Bearing Committee in bolstering industrial preparedness for the national defense.

The primary purpose of the meeting was to consider the reports and recommendations of the two Subcommittees which had held meetings on the previous day.

The newly appointed chairman of the Subcommittee on Technical Standardization, R. B. Walker, New Departure Division, General Motors Corporation, reported on the work of his Subcommittee. He also stated that among its new work would be the completion of tolerance standards on flanged miniature bearings and dimensional standards on separable inner ring bearings.

A. J. Ruffini, Navy Bureau of Ships, stated that there was a continuing problem in the military services with 150 new catalog items a month being received in the ball-bearing category. He stressed the need for coördination of Government agencies, instrument builders, and bearing manufacturers, expressing the hope that further standardization of common instrument bearings would ease the supply and inventory situation.

F. V. Johnson, presented the report of his Subcommittee on Torque and Vibration. This Subcommittee had met on the previous day with the Military Task Group, headed by C. F. Fogarty of the Office of Assistant Secretary of Defense, and including A. E. Rahm, WADC, Wright-Patterson Air Force Base, and Mr. Ruffini, as well as M. E. Taylor of Frankford Arsenal.

A general discussion developed the following points:

1. The military group and the Subcommittee are now in essential agreement on all points at issue on MIL-STD-206.

2. Correlation of the MIL-STD-206 tester with other testers is a matter that can best be handled by individual companies.

3. The cost of the MIL-STD-206 tester is approximately $5,000 with recorder.

4. A very important point in connection with maximum torque specifications is that most users specify these in terms of starting torque but do not always state this definitely.

5. Military personnel from Memphis Air Force Depot felt that there was an urgent need to invoke MIL-STD-206 as soon as possible and to tie down torque specifications where applicable.

6. Bearing company representatives felt that judgment and discretion should be exercised in specifying torque levels, with due regard to practical operations of military inspection activities and the possibility of developing unrealistic and arbitrary curtailment of supply in case of national emergency. (*Contd. on p. 1000*)

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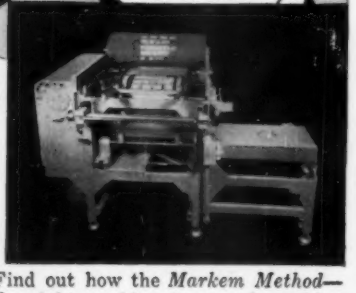

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Brig. Gen. R. C. Mangrum Addresses Luncheon Meeting of Washington Post

The Washington Post met at a luncheon at the Army-Navy Country Club on February 21st to welcome Brig. Gen. R. C. Mangrum, Deputy Assistant Chief of Staff for Planning, Marine Corps Headquarters, and a leader in Marine aviation.

Prior to the general introductions, Col. F. B. Reybold, Post president, announced the Thirty-ninth Annual Meeting of the national Association on May 6th, at Eglin Air Force Base. He also introduced R. P. Williams, a former vice-president of the Post, who recently formed the Williams Engineering Company, consulting engineers.

The following distinguished guests were introduced: Brig. Gen. W. E. Rentz, U.S.A.F., Deputy Chief of Staff for Installations; Rear Adm. Rawson Bennett, Chief of Naval Research; E. V. Murphree, Special Assistant to the Secretary of Defense for Guided Missiles; Lieut. Gen. C. B. Magruder, U.S.A., Deputy Chief of Staff for Logistics; Rear Adm. J. H. Sides, Deputy Special Assistant to the Secretary of Defense for Guided Missiles; E. A. Tupper, Post vice-president; and G. M. Riveire, national council representative.

General Mangrum gave an outstanding review of the weapons and tactics of the Marine Corps, present and future. He noted that the Marines take full advantage of the technical advances in all services in addition to instigating their own. The general described the new vertical-envelopment tactics in amphibious operations and the new weapons and vehicles under development. The audience was convinced that the Marine Corps, as ever, is keeping its armament at top efficiency.

On January 17th over 300 of the Post members gathered at the Army-Navy Country Club to hear an address by Rear Adm. William F. Raborn, director, Special Projects Office, Navy Bureau of Ordnance. Admiral Raborn gave his views on the use of long-range missiles by the Navy in a very interesting discussion of strategical and tactical concepts.

The admiral pointed out that the Navy needs and can use both air-breathing and ballistic types of missiles. He inferred that we can expect greater accuracy from air-breathing missiles which the Navy would need to pinpoint vital targets. However, the ballistic missile also will be most useful when it is finally developed. He especially noted that the Navy had an advantage in missile fighting in that its shipborne missile-launching stages could never be detected for a counter attack by plotting back the trajectory.

The distinguished array of important guests at the speakers' table included Maj. Gen. John P. Daley, director, Special Weapons Division, Office, Chief of Research and Development, U. S. Army; Maj. Gen. F. A. Hansen, chief, Field Service Division, Office, Chief of Ordnance; Rear Adm. P. D. Stroop, Deputy Chief, Navy Bureau of Ordnance; Richard E. Horner, Assistant Secretary of the Air Force for Research and Development; Gen. T. D. White, Vice Chief of Staff, United States Air Force; W. H. Martin, Director of Research and Development, Department of the Army; Maj. Gen. August Schomburg, Assistant Chief of Ordnance for Research and Development, U. S. Army; Rear Adm. J. E. Clark, Director of Guided Missiles, Office, Chief of Naval Operations; and Ernest A. Tupper, American Can Company, Washington, D. C., vice-president of the Washington Post.

The presiding officer, Post President Franklin B. Reybold, announced that the Washington Post had the highest percentage increase in membership for any Post in 1956 and that its numerical increase of 380 was greater than any Post except Los Angeles.

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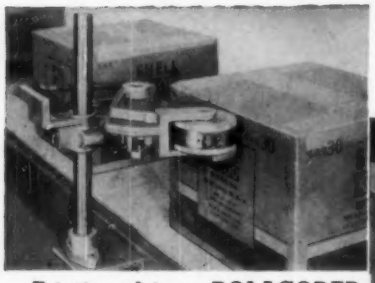

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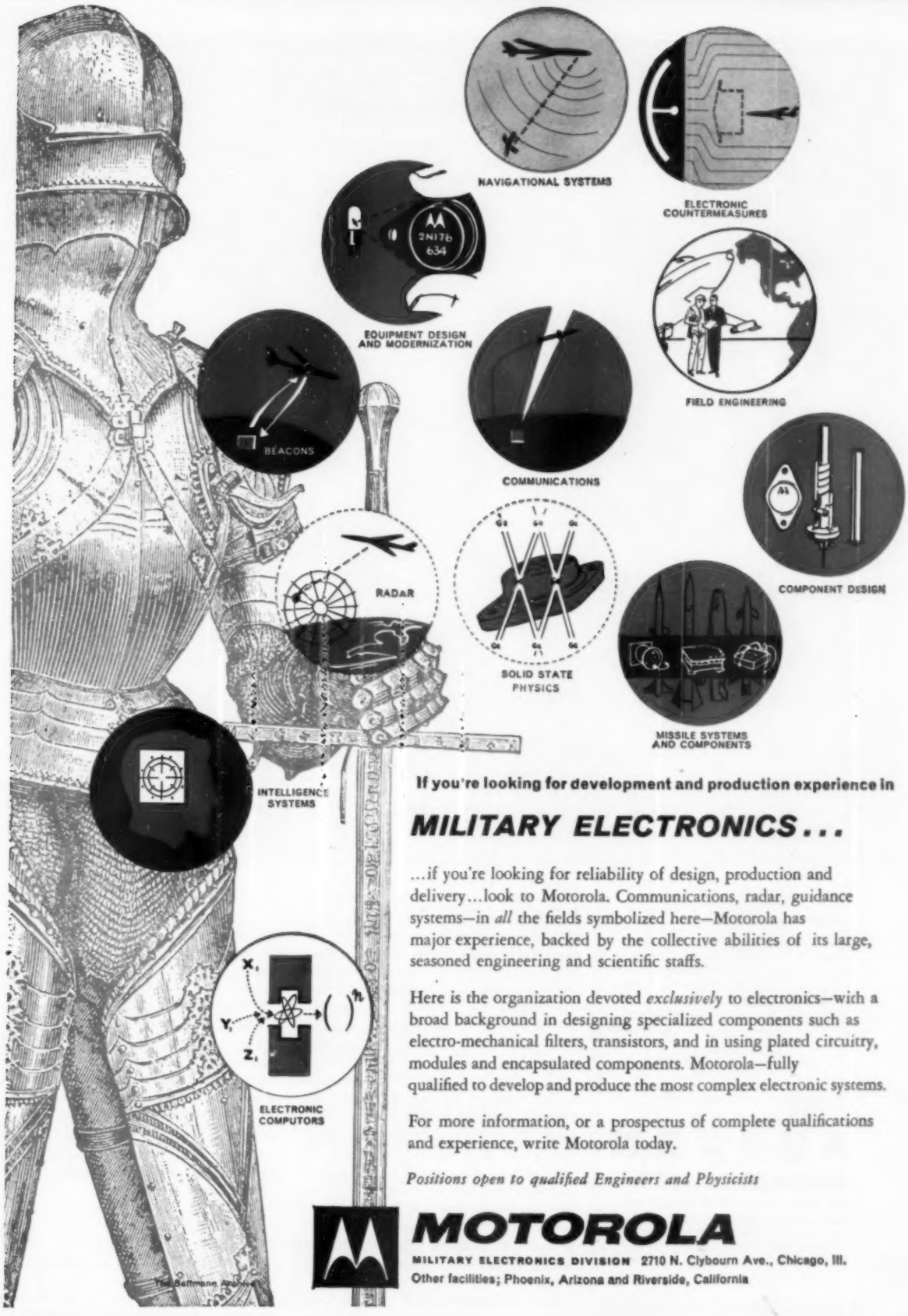
Lieut. Gen. E. L. Cummings Is Guest of Honor at Albuquerque Post Meeting

Members of the Albuquerque Post of the Association were most fortunate to have as guest speaker at their dinner meeting of January 29th Lieut. Gen. Emerson L. Cummings, Chief of Ordnance of the Army. The meeting was held at the Coronado Club of Sandia Base, Albuquerque, N. Mex.

General Cummings and his party of twelve high-ranking officers and civilians of the Ordnance Corps were visiting the base on a tour of installations. General Cummings was greeted by Rear Adm. Frank O'Beirne, commander, Field Command, Armed Forces Special Weapons Project; Maj. Gen. Kenner Hertford, U. S. Army, Ret., manager, Albuquerque Operations, AEC; and Brig. Gen. W. J. Ryan, U.S.A., deputy commander, Sandia Base. A reception at the Officers' Club by the base officers was followed by an A.O.A. reception prior to the dinner at 7:30 p.m. (*Contd. on p. 1002*)



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General Cummings' address, "The Industry-Ordnance-Team," was of outstanding interest to all A.O.A. members. The general stated:

"While each of us appreciates the terrific potential of special weapons, we cannot confine our efforts wholly to them. We in Ordnance have progressed and will continue to progress in increasing the firepower of our so-called conventional weapons.

"For example, whether atomics are used on a future battlefield or not, the tank will continue to be a most essential weapon. Let's assume the probability that atomic weapons *will* be used on the battlefield. Protection of the soldier will be at a premium. The relatively high degree of protection offered by the tank makes it an even more effective and useful weapon in the future.

"Our greatly increased firepower cannot be applied with full effectiveness unless we have it at the proper place at the proper time. The key to this problem is mobility—whether we are speaking in terms of land, sea, or air. I can assure you that we are devoting much time and effort to this problem in our field. While we are concentrating efforts to increase mobility, we are constantly reducing weight to permit better air transportability and air drop."

General Cummings also praised the Industry-Ordnance Team with the following remarks:

"We can take justifiable pride in the Army's record in the guided-missile field. This record was achieved through the true coöperation of the Science-Industry-Ordnance Team. And there are no 'silent' partnerships on this team.

"Specifically, a major portion of the credit for the successful development of our Army weapons systems of all types we attribute to the foresight, vigor, and dedication of science and industry which have joined with us in developing, testing, and producing them.

"This team produces the best results when the efforts of each member are integrated—just as the triple requirements of firepower, mobility, and communications are inseparably related to achieve the best results for the Army.

"In striving to meet our goals, Army Ordnance is linked with industry in still another partnership. The American Ordnance Association has for nearly forty years provided an avenue for the exchange of ideas and information between industry and the Army."

Maj. Gen. E. P. Mechling Addresses Meeting of the Birmingham Post

One of the largest groups of members of the Birmingham Post of the Association met at the Birmingham Country Club, Birmingham, Ala., on the evening of Friday, January 18th, for the twenty-seventh annual meeting of the Post.

It was a gala occasion, marked by a timely address by Maj. Gen. Edward P. Mechling, commander, Air Force Armament Center, Air Research and Development Command, Eglin Air Force Base, Fla. Col. William J. Rushton, president of the Post, was toastmaster.

Preceding the dinner a reception was held in General Mechling's honor at which more than 300 members of the Post were in attendance.

General Mechling in his address described in detail the weapons system philosophy of the Air Force under which qualified private manufacturers are given the task of designing and developing aircraft with all the armament and other appurtenances. Thus the responsibility, under Air Force guidance, rests upon the one producer for the over-all characteristics of the completed aircraft and of its major components, including airframe, engine, and armament.

General Mechling described the application of this method at the Air Armament Center and throughout the Air Force. While it differs in many respects from the time-honored methods pursued by the Army and Navy it has, nonetheless, many elements in common with them.

Especially prepared for this meeting was a commemorative program beautifully printed under the direction of Col. Roy D. Hickman, a director of the Post. The program contained a composite history of the Birmingham Army Ordnance District and the Birmingham Post, A.O.A. Both organizations have worked in closest unison throughout the entire 27-year period.

The program contained photographs of the district chiefs, deputy and executive officers of the period as well as officials of the Post. The brochure is an excellent portrayal of the effective work performed by Army Ordnance, fortified by the A.O.A., in the extremely important industrial area which comprises the district and the Post.

Col. Leo A. Codd, executive vice-president of the A.O.A., also addressed the meeting. He described the status of the Association and some of its present problems and plans.

The following officers for the ensuing year were elected: President, Richard M.

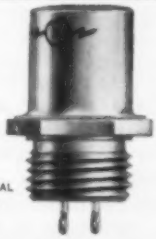
Air-to-air missiles must be guided from the mother plane during that brief interval between the closing of the firing switch and the instant the missile locks on its target. This is the critical moment when a success or failure depends upon the exactness with which computers in the mother plane direct the missile's flight. This is the moment when nothing is as vital to the kill as the precision voltage reference system controlling the computers.

For jobs like these, electronic manufacturers have learned to depend upon Hoffman Semiconductor Zener Reference Diodes. Engineered for use in all types of precision power supplies, these amazingly rugged silicon junction components typify the continuing leadership of Hoffman in the semiconductor field.

Hoffman subminiature Zener Diodes deliver predictable outputs to ±1 per cent over a temperature range from −65°C to +150°C—withstand ± 15G vibration, 100G shock and 50G acceleration loads under the severest humidity and altitude environments.

Whether for analog and digital computers, missile control, telemetering, limiting, clipping, voltage regulation or power supplies where size, weight and stability are critical requirements—Hoffman Semiconductor Zener Diodes are the indispensable voltage reference source.

Hoffman engineers will be glad to supply additional information on request.



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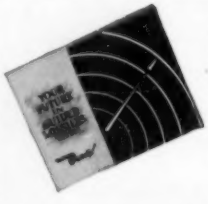
There is no question about it—guided missile engineering is definitely the newest and most modern business, and, logically, the best future for engineers is working with a prime contractor on one of the nation's most important missile projects.

So that you may investigate thoroughly the many advantages of becoming a Bendix Guided Missile engineer, we have prepared a thirty-six-page booklet giving the detailed story of the function of the various engineering groups, such as ram-jet propulsion and hydraulics, guidance, telemetering, steering intelligence, component evaluation, missile testing, environmental testing, test equipment design, system analysis, reliability, and other important engineering operations.

If you'd like to combine the advantages of living in the Middle West and an unparalleled chance for professional growth with one of the world's foremost missile builders, just mail the coupon today for your copy of the booklet "Your Future in Guided Missiles".

Bendix—prime contractor for the TALOS MISSILES



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Gentlemen: I would like more information concerning opportunities in guided missiles. Please send me the booklet "Your Future In Guided Missiles".

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Association Affairs (Contd.)

Donahue, Line Material Company; Vice-presidents, A. B. Schwarzkopf, United States Pipe and Foundry Company; J. Frank Curry, Protective Life Insurance Company; Treasurer, Robert D. Cotten, Clark-Cotten Mortgage Company; Secretary, Ralph E. Parker, Birmingham, Ala.

The following directors also were elected: K. V. McMasters, Sherwood Moore Iron Works; Lindsey Builder, Rudisill Foundry Company; William J. Rushton, Protective Life Insurance Company; Arthur V. Wiebel, Tennessee Coal & Iron Division, U. S. Steel Corporation; F. L. Pyle, Spencer Chemical Company; Herbert E. Smith, Jr., Vulcan Rivet & Bolt Corporation; Thomas Erby Kilby, Jr., Kilby Steel Company; Russell C. Harris, Harris Foundry & Machine Company; P. S. Knox, Jr., Knox Metal Products Company; Russell H. Pedigo, consulting engineer, Leland, Miss.; Roy D. Hickman, Alabama Engraving Company; J. Alan Muller, Redstone Arsenal.

Colonel Rushton was elected representative of the Birmingham Post on the national Council and Warren Whitney, James B. Clow & Sons, was chosen member at large of Council.

Colonel Rushton, who retired as president of the Post, was the recipient of congratulations for his splendid contributions to both the Ordnance District and the A.O.A. over the years. He was formerly chief of the district and is presently a regional vice-president of the Association. Much of the success of both organizations has been due to his leadership and devotion.

Powder Metallurgy Committee of Advisory, Technical and Research Group Meets

The winter meeting of the Powder Metallurgy Committee, Advisory, Technical and Research Group, A.O.A., was held at Dayton, Ohio, with "Andy" Langhammer, chairman of the Committee presiding. After opening the meeting, the chairman introduced C. J. Werner, general manager, Moraine Products Division, General Motors Corporation, whose splendid facilities were graciously made available for this technical meeting. Mr. Werner welcomed the members of this important Committee of the A.O.A. and in a few well-chosen words briefly described the operations of this division of the General Motors Corporation.

Mr. Langhammer then outlined the procedure which would be followed in handling this important technical meeting —the morning session to be devoted primarily to the presentation of the reports

New Design Trends for

Harvey Aluminum Extrusions

To any experienced engineer or designer, aluminum extrusions are a common commodity. You don't have to tell him that extrusions offer such advantages as ease of fabrication, design flexibility, etc. He knows that. What he wants to know now are the newest advances made possible by the extrusion process.

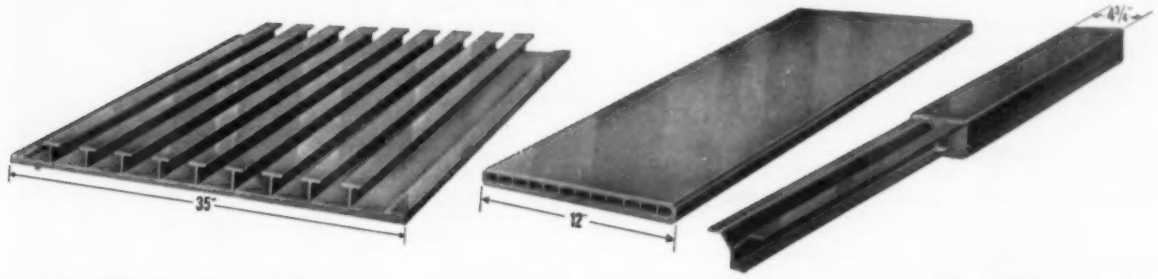
Potential for new configurations and applications

Typical new applications for Harvey Aluminum Extrusions are illustrated below. The design possibilities for aluminum extrusions are now practically limitless. Large heavy press sections; unusually complex shapes; wide, integrally stiffened skin panels; solid, hollow, and stepped extrusions; and extra long thin sections can be obtained from Harvey in all aluminum alloys. Heat-treated shapes can be produced in lengths up to 80 feet, weighing as much as 2,500 pounds. The maximum circumscribing circle diameter practical is 25½ inches. For functional, structural, or decorative applications demanding custom design plus light weight, corrosion resistance, high strength, and a naturally attractive finish, Harvey Aluminum Extrusions are first choice. And remember, Harvey is traditional for high quality and service.

Harvey Aluminum leads in extrusions

Harvey's completely integrated facilities include a large complement of extrusion presses ranging in size from 1400 tons to 12,000 tons, stretch-straighteners up to 3,000,000 pounds capacity for lengths up to 105 feet, and the newest supporting and finishing equipment.

If you have a problem with extrusions, thoroughly qualified Harvey specialists are always ready to help you improve your product. Write to Harvey Aluminum Sales, Inc., Torrance, California, or contact the nearest sales office listed under "Aluminum" in your classified telephone directory.



INTEGRALLY STIFFENED SKIN PANEL is produced in extra wide widths on heavy presses. Combination of skin and stiffeners in large panels minimizes machining, simplifies assembly, improves performance of aircraft, missiles, and military vehicles.

DECK COOLING PANEL for aircraft carrier is extruded on heavy presses. Light-weight, water-tight aluminum panels circulate water to offset intense heat generated against deck in jet aircraft operations.

STEPPED EXTRUSION for aircraft structural member eliminates machining and reduces assembly time. Aluminum part is lighter and stronger than outmoded built-up section formerly used.

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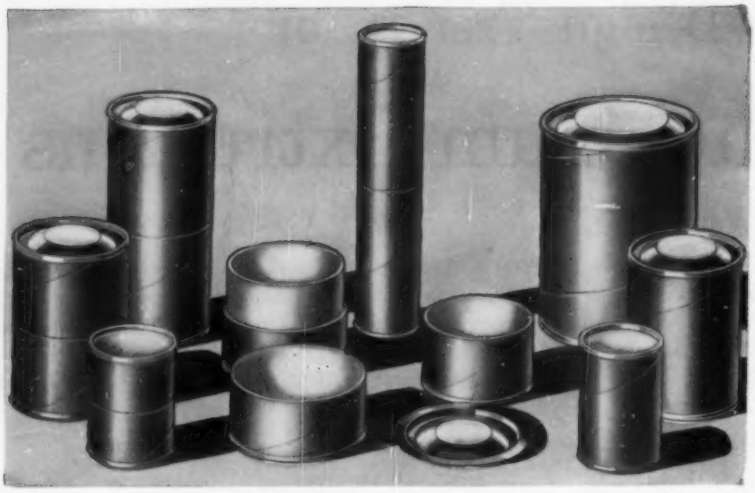

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Cut costs . . . save time . . . by taking advantage of our tooling for more than 100 diameter sizes. This variety of sizes will provide a container for almost any spare parts item you want to package.

These basic fibre containers meet all present day military and civilian specifications.

This diversified packaging service . . . the convenience of our plants . . . ensure PROMPT DELIVERIES . . . with added savings to you.

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Made to conform to both grades of MIL-C-3955, Type II, or MIL-C-2439 and other specifications. Produced in diameters from ⅞" and in lengths desired. This container is easily sealed by use of tape to specification JAN-B-127.

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Made to conform to MIL-C-3955, Type I and other specifications. Diameters from 1" and in lengths as required. One metal end seamed on, the other end shipped loose. A machine for attaching the loose end is available on a rental basis.

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by the chairmen of the various groups and Subcommittees of the main Committee, and the afternoon session to be devoted to discussions of the papers presented during the morning and ending with a discussion of future plans and preliminary arrangements for the spring meeting of the Committee at the Westchester Country Club, Rye, N. Y., on May 24, 1957.

The chairman then introduced Kempton Roll, executive secretary of the Metal Powder Association, stating that Mr. Roll had accepted the permanent secretaryship of the Raw Materials Group of the A.O.A. Powder Metallurgy Committee. This close relationship between the Metal Powder Association and the Powder Metallurgy Committee of the A.O.A. will facilitate this Committee always having the most up-to-date data and statistics on the availability of raw materials.

The chairman then proceeded with the

Andrew J. Langhammer

technical session of the meeting, calling upon the chairmen of the various Groups, Subcommittees, and Task Forces for their report on activities, since the last meeting. These reports of the chairmen had been prepared with great care and were highly informative, and copies were distributed later to all Committee members.

Following the magnificent luncheon provided by their host—the Moraine Products Division—the Committee reconvened for the discussion period. During the afternoon session representatives of the armed services were called upon for their comments and remarks including Colonel Klinker of the Ordnance Corps; Dr. Lucas with the ABMA; Mr. Davis of the Diamond Ordnance Fuze Laboratories; Mr. Littleford, Lake City Arsenal; Mr. Michaud, Picatinny Arsenal; Commander Dubyk of the Navy Bureau of Ordnance; Mr. Hartley of Wright-Patterson Air Force Base; and Mr. Blittendorf of Frankford Arsenal.

(*Continued on p. 1008*)

DOW CORNING CORPORATION

Silicone Dielectrics

ELECTRICAL AND ELECTRONIC NEWS No. 11

SILASTIC HELPS MEAT THERMOMETER TAKE GUESSWORK OUT OF ROASTING

Because Silastic* stays rubbery and retains its dielectric properties at temperatures from —130 to 500 F, its use is expanding in many industries. New applications for Dow Corning's silicone rubber range from jet aircraft to this electric meat thermometer developed by King-Seeley Corporation, Ann Arbor, Michigan.

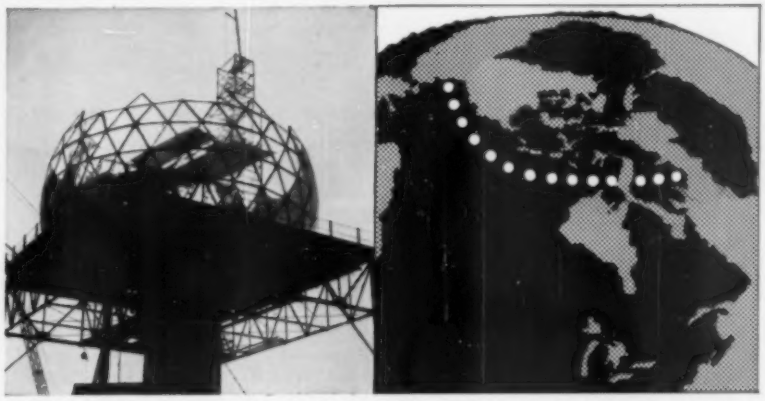
A highly practical tool for professional and amateur cooks alike, King-Seeley's meat thermometer consists basically of a thermistor sealed inside a probe. When inserted into a roast, the thermistor quickly translates meat temperature into electric current which indicates on a dial the degree to which the meat is "done."

Silastic is used to cover the flexible lead wire running to the probe because it remains resilient and retains good dielectric properties despite frequent and sometimes lengthy exposure to 500 F oven temperatures. In addition, since Silastic transmits neither odor nor taste even at these high temperatures, two spring-compressed

Silastic washers seal the probe and prevent contamination of the thermistor.

Philco was first to offer the King-Seeley thermometers on kitchen ranges, under the trade- name "Roastmeter." Hot Point, Magic Chef, and Cribben & Saxton ranges also feature it now. Other manufacturers have either arranged to include the meat thermometer in their line or are considering its early adoption. *No. 45*

*T.M.REG.U.S.PAT.OFF.



"DEW LINE" RELIES ON DRY-TYPE TRANSFORMERS INSULATED WITH DOW CORNING SILICONES

New testimony to the extra reliability of Dow Corning silicone electrical insulation is provided by the transformers of the "DEW" defensive radar line now under construction north of the Arctic Circle.

In these remote yet vital installations, dependability and maintenance-free service are essential. That's why Western Electric Company, prime contractor for "DEW" electrical equipment and installation, specified silicone insulated dry-type transformers right down the Line. Most of the units, supplied by the Pittsburgh works of Allis-Chalmers have been installed.

Designed for maximum dependability, minimum weight and a 302 F (150 C) temperature rise, the transformers range in size from 25 to 75 KVA. They are completely sealed and will withstand ambient temperatures as low as —60 F (—51 C) when idle.

While used primarily for station light and power, the DEW Line silicone insulated transformers will handle power for the radar signal in an emergency. *No. 44*

REDUCE ELECTRICAL FAILURES WITH DOW CORNING 3 COMPOUND

Want maximum protection against shorts, grounds and arcs caused by moisture, water, dust and corrosive fumes? Then try versatile Dow Corning 3 Compound.

A grease-like, silicone water-repellent, Dow Corning 3 is the ideal dielectric for filling voids and coating insulating parts in electrical and electronic equipment. Also protects cable insulation from oxidation; keeps rubber parts soft and flexible.

You can use Dow Corning 3 to prevent corrosion, too. Many maintenance men keep several tubes handy for use on disconnect switches, cable connectors, battery terminals, fuse cartridge clips and other electrical and electronic fixtures. A thin film of this silicone compound provides long-time protection at temperatures from —40 to 400 F. For free sample and more information, circle ..... *No. 46*

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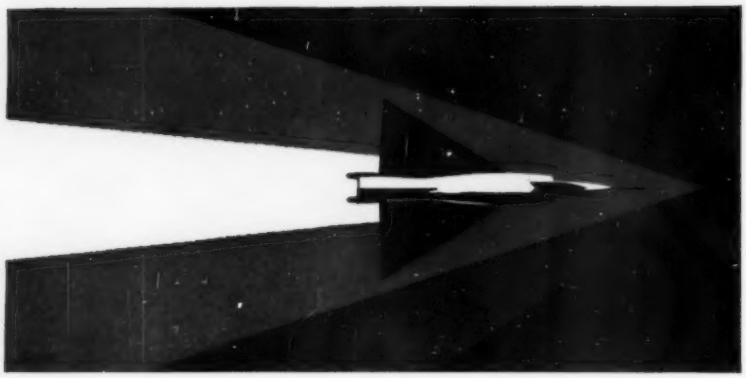
Canada: Dow Corning Silicones Ltd., Toronto; **Great Britain:** Midland Silicones Ltd., London; **France:** St. Gobain, Paris

FROM A STEEL TEST TUBE —TOMORROW'S AIRCRAFT!



■ The punishment imposed on air chambers and tunnel walls of the NACA's huge new Langley Aeronautical Laboratory wind tunnel demanded an exhaustive study of all available materials of construction. The requirements: proved reliability and endurance in the face of high pressures and corrosive attack.

Two special duty steels survived that critical examination: for the chambers—Lukens "T-1" brand, with a yield strength of 90,000 psi yet readily weldable; and for the tunnel—Lukens stainless-clad "T-1", a composite of the high and lower alloy content steels permanently bonded into a single steel plate.

The above is just one example of how Lukens broad range of special purpose steels are contributing to the improved design and performance of modern defense equipment. Find out more about them, how they fit your needs. For copies of the informative, illustrated booklets, LUKENS "T-1" STEEL and CLAD STEEL EQUIPMENT, *or* for information concerning your specific problem, address Manager, Marketing Service, 904 Lukens Building, Lukens Steel Company, Coatesville, Pa.

LUKENS ®

Helping industry choose steels that fit the job

Association Affairs (Contd.)

Toward the close of this afternoon session, Louis Polk, A.O.A. vice-president in charge of Technical Divisions and Committees, joined the group. Chairman Langhammer introduced Mr. Polk and called upon him for a few remarks, especially along the lines of inspection and testing which had been so prominently considered throughout the day's meeting.

Mr. Polk delivered an inspiring talk expressing appreciation of the outstanding work being accomplished by this important Committee, and his enthusiasm stirred all present to attempt even greater performance in the months ahead.

Shell Committee Meeting Is Attended by 150 Members at Atlantic City, N. J.

The annual meeting of the Shell Committee, A.O.A. Bomb and Artillery Ammunition Division, was held at Atlantic City, N. J., with Walter N. Howley, chairman of the Committee, presiding. This was a large well-attended meeting of approximately 150 people interested in the design, development, and production of the metal components of artillery shell.

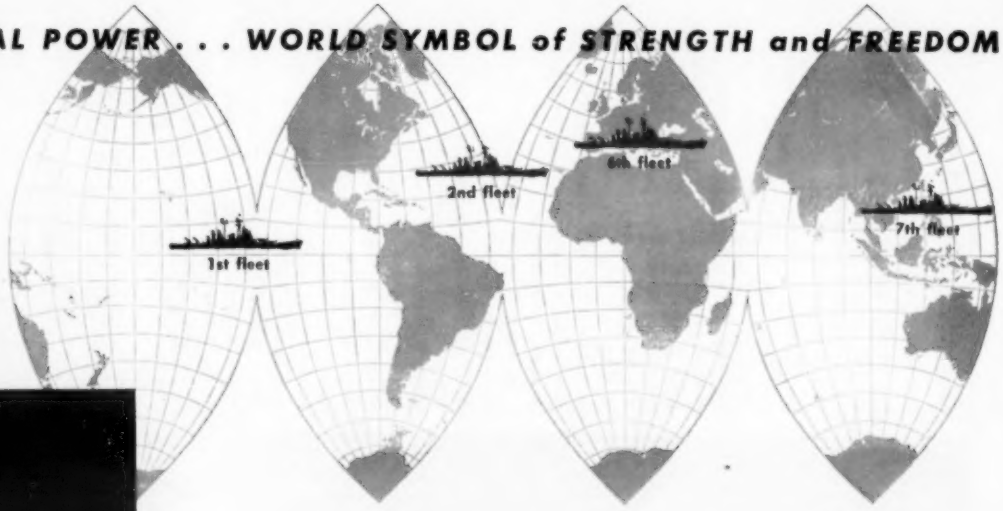
Walter N. Howley

At the opening of this important meeting, Mr. Howley described the scope of this particular meeting as follows:

"As to the reason for developing the agenda as we have arranged it for this meeting, all of us know that in the success of the production of any item it is very necessary to have the close coöperation of the people who supply us with materials, equipment, and so forth. No commercial manufacturer has ever been able to produce successfully without that coöperation and advice. So we have asked representatives of the Machine Tool Industry, the Heating Industry, the Fuel Suppliers, the Gage Makers, and the Tooling people to come to this meeting to pre-

U. S. NAVAL POWER . . . WORLD SYMBOL of STRENGTH and FREEDOM

The General Electric AN/SPS-8 radar atop the mast of the USS Boston.



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. . . thru Electronic Systems

Powerful U. S. Naval forces assigned to various strategic ocean areas of the world are vigorous and effective ambassadors of freedom and strength. Requiring no foreign bases to make their presence known, they act as a deterrent and forward defense against any would-be aggressor.

These mobile naval forces pack a nuclear defense and offense capability second to none. Supersonic jet aircraft, missiles and potent undersea warfare weapons are but a few of the growing arsenal that they have ready to use if attacked.

Lightning-fast electronic systems function as the nerve center for target information and control of these roving forces. The AN/SPS-8 height-finding radar developed and built by the HMEE* Department of General Electric is an almost indispensable source of information aboard all our naval ships having an air intercept capability.

Engineers interested in a challenging opportunity, write for brochure "Electronic Systems—Key to Our Nation's Defense". General Electric Company, HMEE Department (12), Syracuse, New York.*

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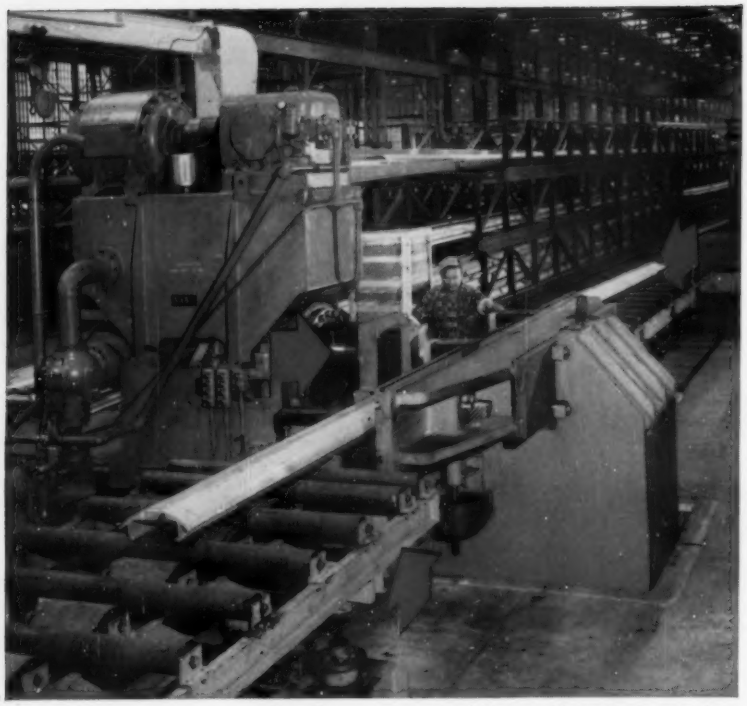
*HEAVY MILITARY ELECTRONIC EQUIPMENT DEPARTMENT • SYRACUSE, N.Y.



Live-roller conveyor moves work into press. Conveyor moves up or down to position work in die. Ram moves forward to straighten work. Entire installation, including press and conveyor, designed and built by Farquhar.

Kaiser Aluminum uses this Farquhar HORIZONTAL BULLDOZER PRESS for fast-cycle straightening

Aluminum extrusions, fed *continuously* to the press on Farquhar Live-Roller Conveyors, are straightened in a *fast-cycle operation* on this Farquhar 500-ton Horizontal Bulldozer Press. This efficient set-up is installed at the U. S. Air Force Heavy Press plant operated by Kaiser Aluminum & Chemical Corporation in Halethorpe, Maryland. In their own words this press is used "to eliminate natural bows and deformations which develop in some aluminum extrusions after they have been heat treated."

Like Kaiser Aluminum, major plants in this country have found that these Farquhar Horizontal Bulldozer Presses provide high production at low unit cost. Fed either by crane, overhead or in-line conveyors, they are used to economically forge, stamp, straighten or form parts in an efficient, fast-cycle operation.

Write for complete information on Farquhar Horizontal Bulldozer Presses or, better still, ask for our proposals or recommendations.

Farquhar Special Machinery Department . . .

Our qualified staff will build your special machinery economically—your inquiry will receive prompt attention.

A. B. FARQUHAR DIVISION
The Oliver Corporation
Press and Special Machinery Departments
York 36, Pennsylvania

OLIVER Farquhar PRESSES

Also Manufacturers of Farquhar Conveyors

Association Affairs (Contd.)

sent their views and recommendations to the Service representatives and the shell makers."

Chairman Howley then introduced Col. Henry N. Marsh, general chairman of the Technical Divisions and Committees, and Brig. Gen. B. O. Lewis, staff consultant, national A.O.A. headquarters, both of whom expressed their sincere pleasure at being present at this meeting and made a few remarks. Col. Leo A. Codd, executive vice-president of the Association, was then introduced with appropriate remarks by Chairman Howley. Colonel Codd delivered a stirring address on, "The American Ordnance Association's Tradition for Armament Preparedness."

In concluding his remarks, Colonel Codd stated, "You men of this A.O.A. Shell Committee, now for ten years—and many of you as members of the Ordnance Association for twenty and thirty and even thirty-eight years—have been giving most generously of your skill, of your talent, of your time, and of your substance to further the work to which loyalty to the tradition of armament preparedness enjoins us all. I feel deeply that I speak for the nearly forty thousand other members of this Association in saying that your chairman, and you of this Committee, are entitled not only to thanks, but to great honor for what you give."

Walter Howley then proceeded with the following technical agenda of the morning session. The following papers were presented by the Machine Tool Panel:

"Desirable Machine Tool Design in Shell Manufacture," by R. F. Johnson, president, Gisholt Machine Company, Madison, Wis.

"Need for Planning Machine Tool Development with New Ordnance Product Design," by R. T. Frisbie, Jr., vice-president, New Britain Machine Company, New Britain, Conn.

"How Machine Tool Research Should Be Planned for the Future," by David N. Smith, manager of research, Jones & Lamson Machine Co., Springfield, Vt.

The following papers were presented by the Heating & Fuel Panel:

"Review of Past and Future Developments in Connection with Heating and Heat Treating Furnaces," by Henry N. Heyn, vice-president, Surface Combustion Corporation, Toledo, Ohio.

"Availability and Consumption of Gas and Electricity for Ordnance Production," by A. D. Spillman, engineer for industrial application of gas and electricity, Philadelphia Electric Company, Philadelphia, Pa.

The afternoon technical session was devoted to a presentation of the Army Industrial Procurement Panel by the Hon. Frank H. Higgins, Assistant Secretary of the Army (Logistics). (*Contd. p. 1012*)

We Believe that Peaceful co-existence is best maintained by being Too Tough to Tackle

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Intended for use with jacketed cable and not requiring ground return through mating surfaces, this connector incorporates sealing gaskets at all mating joints.

W-Type Bendix* Connectors also incorporate standard Scinflex resilient inserts in established AN contact arrangements. Shell components are thick sectioned high-grade aluminum for maximum strength. All aluminum surfaces are grey anodized for protection against corrosion.

It will pay you to remember that for the really tough jobs, where ordinary electrical connectors just won't do, be sure to specify the W-Type Connector.

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No shock is too much for the Lindsay Pressure Gauge ...proven in guided missiles!

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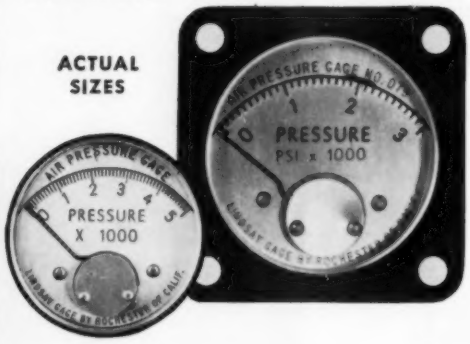
The RMC-Lindsay Pressure Gauge registers steady pressure readings from 500 to 10,000 PSI for extended periods. Not even the most extreme conditions of shock, vibration or temperature disturb its accuracy. It is the one high pressure gauge capable of meeting the tremendous demands of guided missile service, and is currently used in some of the nation's mightiest missiles and aircraft.

The RMC-Lindsay Gauge is a bourdon tube gauge which uses a multiple coil, helical bourdon tube with the pointer attached directly to the end of the coil. As compared to the traditional "C" spring bourdon gauge, the life of the Lindsay helical bourdon coil is more than 10 times greater and its proof pressure limits are increased by a factor of 3 or 4. Also, by using the multiple turn helical bourdon tube there are no linkages and pivots—this improves the gauge's shock resistance by a factor of 5 or 10.

The same basic gauge—with all its rugged, missile-service qualifications—is used for aircraft applications. Lindsay Pressure Gauges for aircraft are made for extensive cycling—will meet rigid endurance and over-pressure requirements. They are made in sizes down to 1″ diameter.

ACTUAL SIZES



The helical bourdon element is, of course, not a new development. However, the RMC-Lindsay techniques in coiling, heat treatment, calibration and material specifications are new—and exclusive with RMC of California.

Whatever your high pressure gauge problems may be, why not let RMC engineering skill provide the answers. Write today, outlining your particular requirements.

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Association Affairs (Contd.)

The Secretary assured the members of the Shell Committee that it is highly important to national defense to have a Committee such as this available now and in the future so that if the occasion arose, they might be called upon by the armed services for technical advice as they have been in the past. Secretary Higgins then introduced the following members of his panel: Maj. Gen. Henry R. Westphalinger, Maj. Gen. Robert G. Butler, Brig. Gen. Jean E. Engler, Col. Nicholas R. Voorhis, Lieut. Col. William W. Thybony, Lieut. Col. William E. Campbell, Mr. J. W. Askins, Mr. Courtney Johnson, Maj. James S. Larson.

The forum presentation was preceded by a short address by General Westphalinger on "What the Battlefield of the Future Will Look Like," and an address by General Engler on "A Forecast of Future Ordnance Requirements."

The meeting was resumed at 10:00 a.m. the next day with Mr. Howley presiding. The following papers were presented:

"Shell and Shell-Type Rocket Head Requirements of the Navy and Army for the Coming Year," by Capt. George B. Stallings, U.S.N., and Col. Glenn E. Nida, Ordnance Corps, U. S. Army.

"Industrial Planning for Gun Ammunition," by Walter L. Tann, Navy Bureau of Ordnance, and Brig. Gen. Joseph M. Colby, commanding Frankford Arsenal.

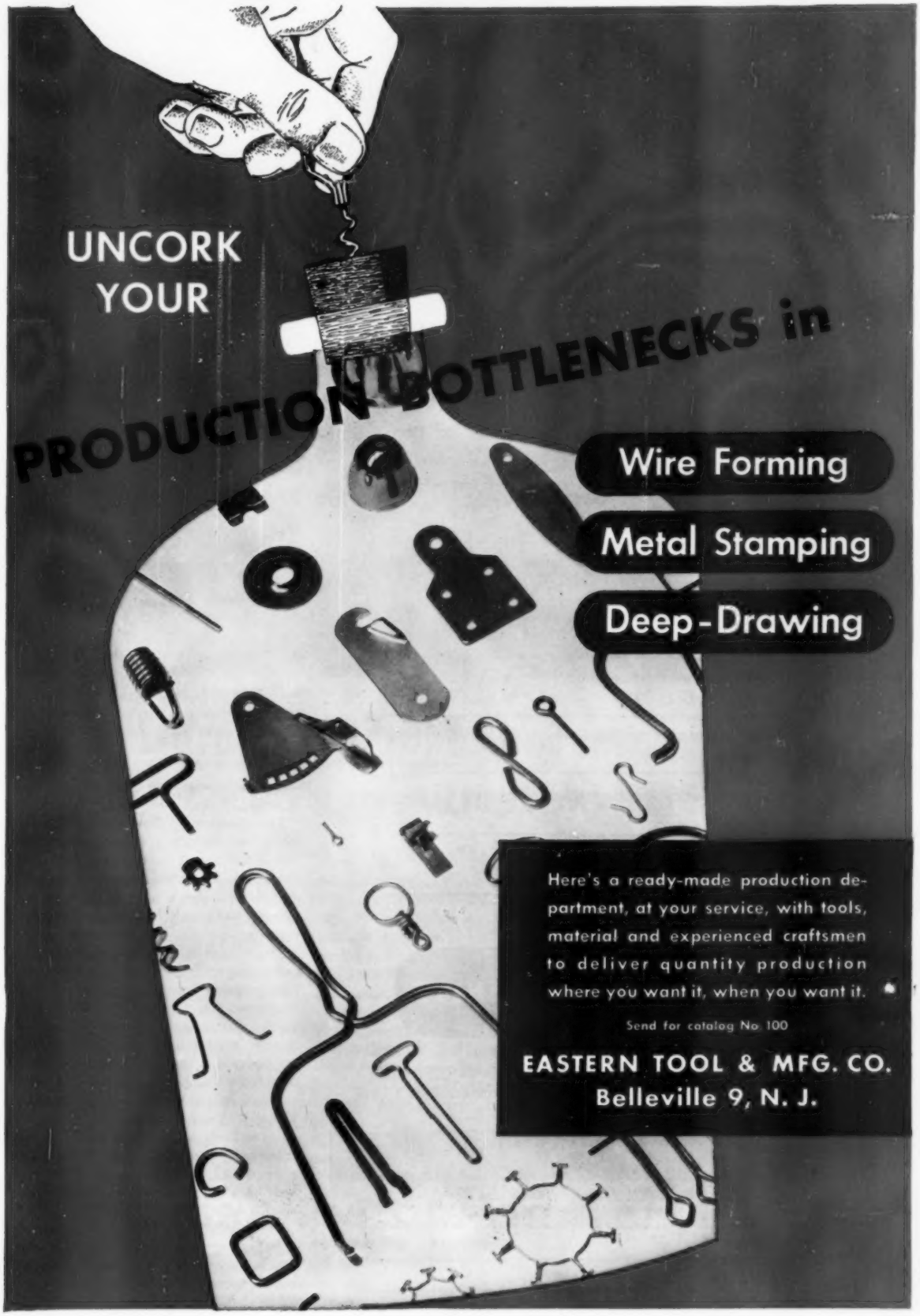
"Automatic Gaging and Related Problems in Present and Future Ordnance." These papers were presented by Col. William J. Darmody, U.S.A. (Ret.), Sheffield Corporation; Franklin Meyer, Jr., chief engineer, Taft-Peirce Manufacturing Company; J. S. Boatch, Pratt & Whitney Division, Potter & Johnson Company.

"Appraisal of the Commercial Uses of Powdered Metals in the Future as They May Affect Ordnance Manufacturing," by A. J. Langhammer, Metallurgy Consultant, Detroit, Mich.

Board of Directors of the Texas Post Holds Luncheon Meeting at Houston, Tex.

The board of directors of the Texas Post held a luncheon meeting at the Houston Club, Houston, Tex., on Monday, March 18th, under the direction of Post President K. P. Campbell, Sheffield Steel Corporation. The guest of honor was F. Ray McFarland, manager, Houston Division, Sheffield Steel.

As the first order of business—the election of officers—it was voted to reelect the present officers and directors. Post Secretary Leo S. Bassett reported on the activities he observed at a recent Lone Star meeting. As a result of Mr. Bassett's report, it was decided to hold the next annual meeting of the Texas Post at the Houston Club on Monday,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1	**How to clean aluminum before anodizing.** See pages 4 to 8.
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5	**How to strip paint from aluminum.** See pages 22 to 26.
6	**How to clean magnesium.** See pages 27 to 29.
7	**How to install cleaning tanks and spray-washing machines.** See pages 31 to 35.
8	**How to control overspray in paint booths.** See pages 36 to 37.
9	**How to clean engine test cells.** See page 40.

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Association Affairs (Contd.)

September 16, 1957, with a special invitation to the ladies.

A committee was established to confer with the University of Houston R.O.T.C. unit about forming a student Chapter.

• **EUGENE PITOU**, founder of the Patent Scaffolding Company, Long Island City, N. Y., died in New York City, December 21, 1956. He was a charter life member of the Association.

A native of New York City, Mr. Pitou was graduated from Columbia University in arts in 1904 and in civil engineering in 1906. He founded the company in 1909 and until his death had held various offices including general manager, president, and chairman of the board of directors. The company is the largest manufacturer in the United States of steel scaffolding for building construction.

As a first lieutenant of the Ordnance Department of the Army in the First World War he served in the Loading Section of the Ammunition Division, New York Ordnance District. He continued in this assignment on the procurement and supply of ammunition until his retirement, April 1, 1919.

A director of several other industrial organizations, he was also a member of the University and Columbia Clubs and the Everglades Club, Palm Beach, Fla.

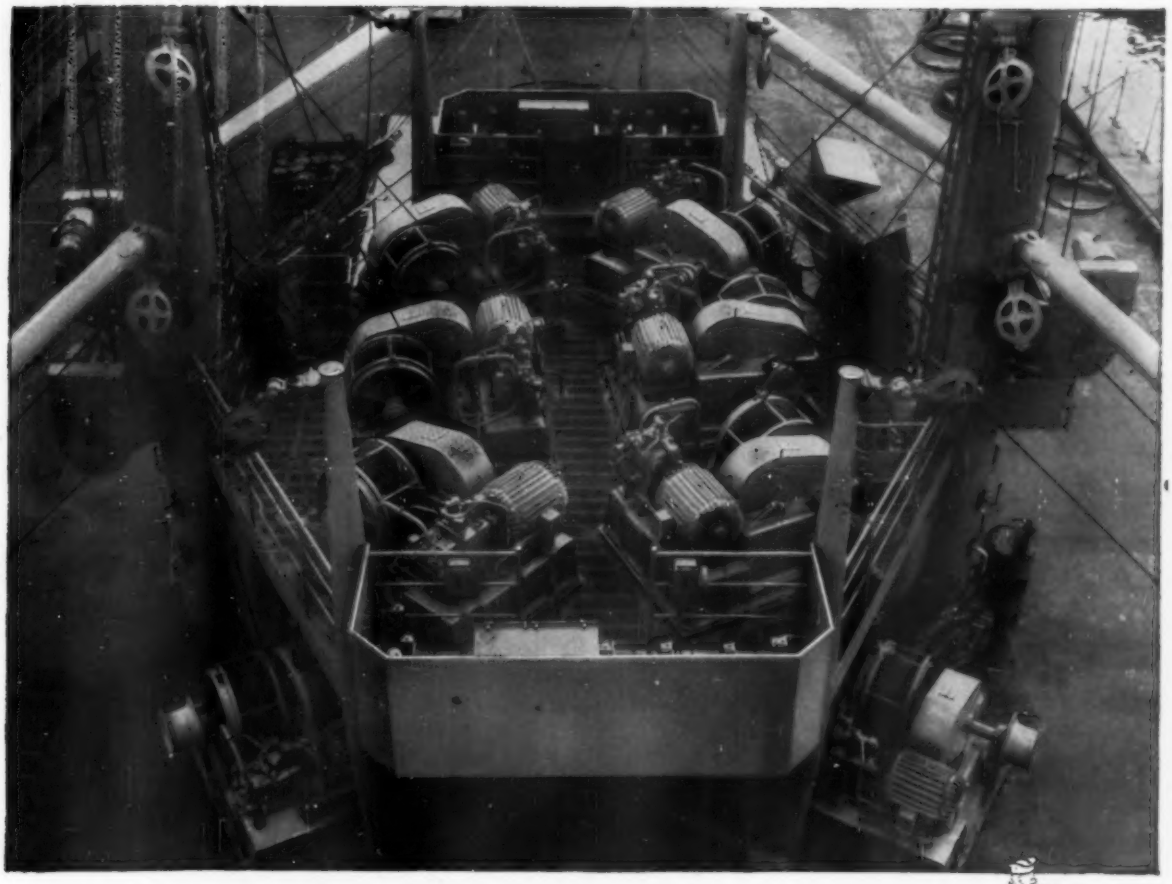
• **GEORGE L. NANKERVIS**, president and founder of the George L. Nankervis Company, died suddenly in Detroit on February 13, 1957. He was a member of the Ordnance Association for many years and recently was elected a director of the Michigan Post.

The Nankervis Company, which he started in 1940, is a major producer of test instruments and equipment used throughout the automotive and aircraft industries and also is known for the engineering and installation of electroplating systems.

Mr. Nankervis came to Detroit in 1913 and began his career as a manufacturer's representative handling metal-finishing equipment and supplies. In 1940 he expanded the activities of his company to include engineering and manufacturing, and today it is engaged in the design and manufacture of highly complex electronic and hydraulic test equipment for automobile and jet-engine testing.

In addition to his prominence in the industrial world, Mr. Nankervis was also a civic and community leader and was well known for his work in youth activities.

He was also a member of the Engineering Society of Detroit, the American Electroplater's Society, and the Newcomen Society.



Hydraulic Winches make shopping faster, safer...on new Seagoing Supermarkets

Fast transfer of food stores at dockside and on the open sea was a *must* for the two new U. S. Navy Seagoing Supermarkets. So the versatile hydraulic winch that outperforms all others was selected—the new Vickers-powered winch built by Lake Shore Engineering.

Why do users consider this new winch better? *Because it gives faster load handling.* Acceleration is faster, smoother than any other drive—reverses in a fraction of a second. *It increases useful operating time.* Instantaneous overload protection and automatic speed reduction drastically cut breakdowns and maintenance. It reduces breakage. Torque is maintained during stall. *It reduces power consumption.* Extremely high torque is exerted at very low output speeds and low input power.

Whenever you need a versatile power source, investigate Vickers hydraulics. We can offer exactly the right hydraulic system (or hydraulic unit) to give the best solution to your marine or ordnance problem.

Write for your copy of *Hydraulics for High Horsepower Application.*

One of two new refrigerator ships built by Ingalls Shipbuilding Corporation for the U. S. Navy. Each vessel has 30 winches powered by Vickers hydraulic transmissions.

Official United States Navy Photographs

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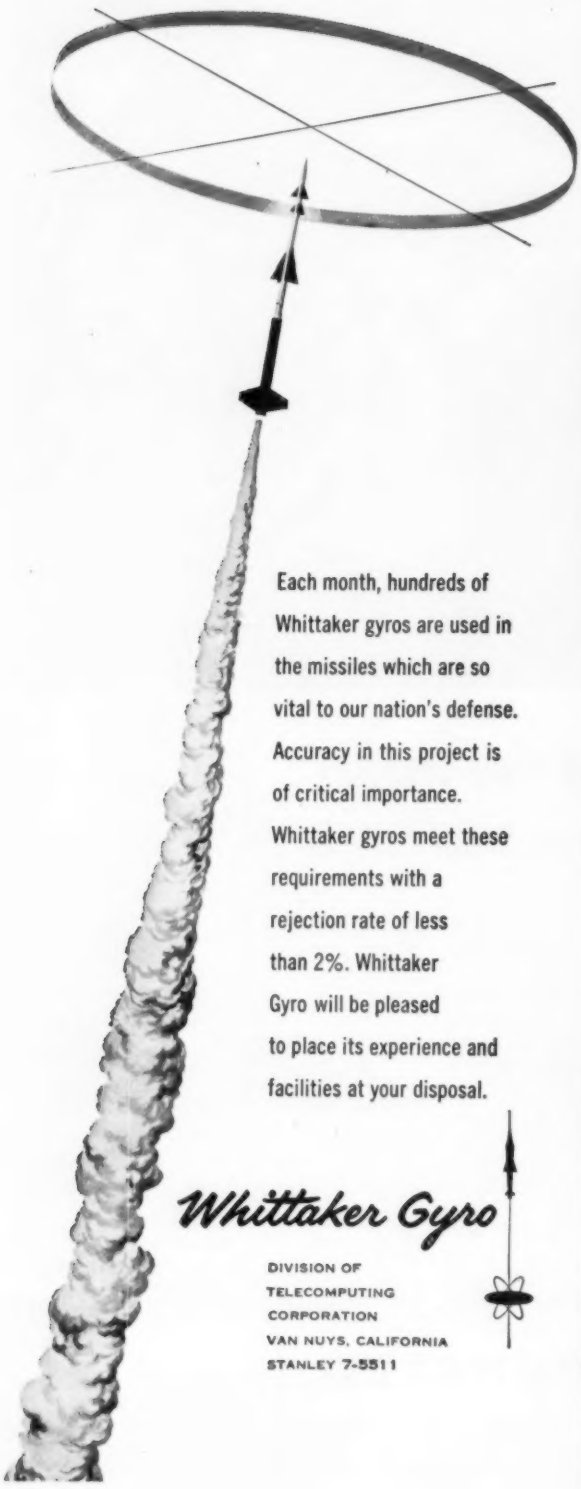

Each month, hundreds of Whittaker gyros are used in the missiles which are so vital to our nation's defense. Accuracy in this project is of critical importance. Whittaker gyros meet these requirements with a rejection rate of less than 2%. Whittaker Gyro will be pleased to place its experience and facilities at your disposal.

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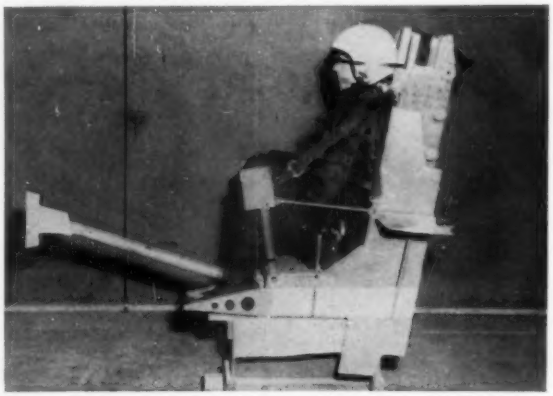
NEW DEVELOPMENTS

"FLYING" EJECTION SEAT

Safe escape from aircraft traveling more than 1,500 miles an hour is the objective of a revolutionary new pilot-ejection system developed by Lockheed Aircraft Corporation and the Air Research and Development Command.

Basically resembling present jet-fighter ejection seats, the new device features (1) vertical fins which extend along each side of its back, (2) stublike wings, and (3) a waffle-sized steel wind deflector mounted on a 4-foot-long boom in front of the occupant. These flight appendages operate at the instant the ejection seat separates from the cockpit.



New supersonic ejection seat.

With the new device jet crew members should be able to eject with safety at stratospheric heights and up to twice the speed of sound—or as low as 400 feet at 850 miles an hour. The seat will then "fly"—completely stable—until a parachute opens automatically at a predetermined altitude and airspeed. After the parachute opens, the seat separates and falls free.

NIKE HERCULES

An improved version of the Nike guided missile, recently designated as Nike Hercules, has nuclear capability and many times the destructive power of the original Nike (see cover photo).

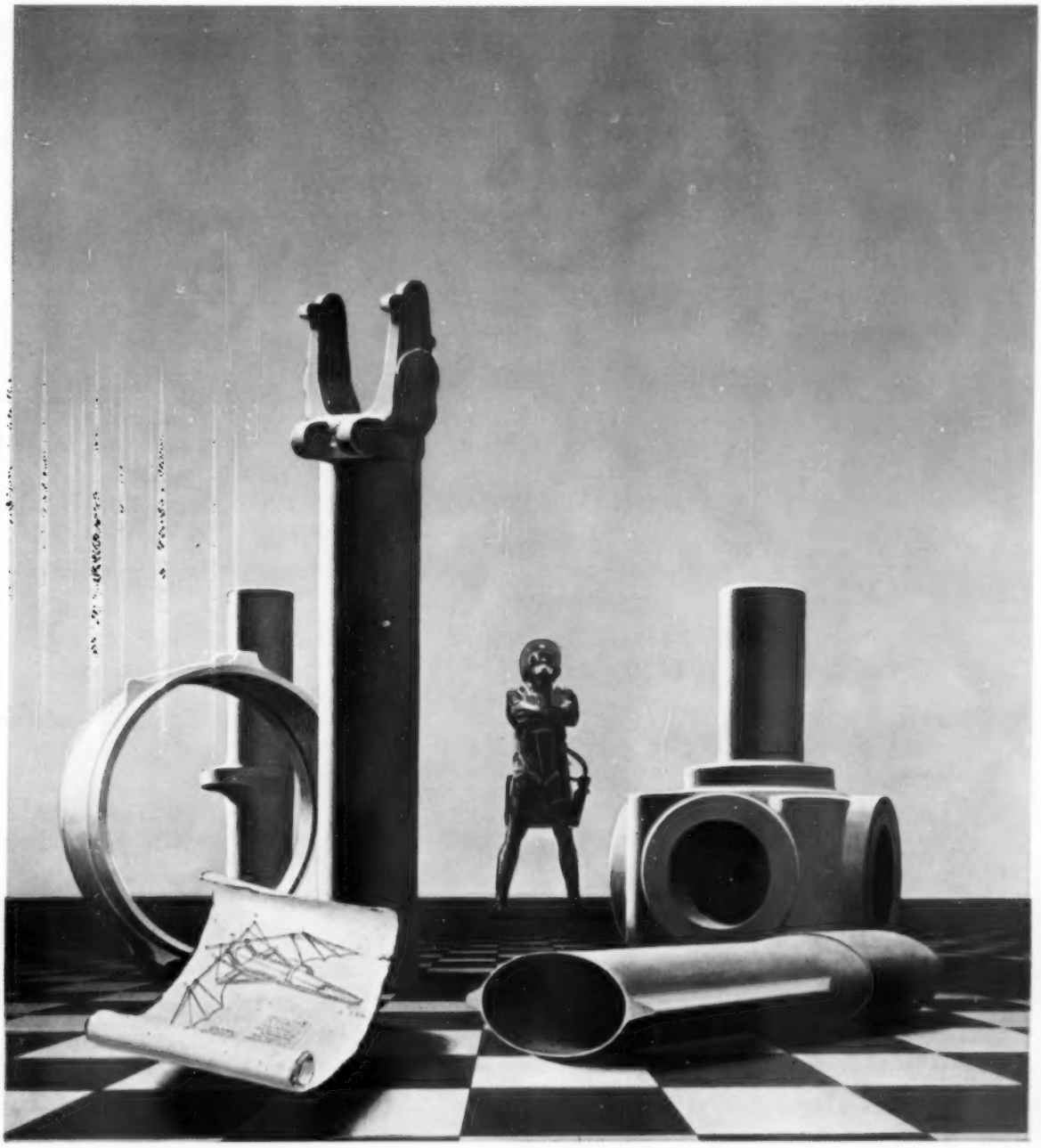
Known as Nike B during its development stage, Nike Hercules is substantially faster and has a much greater range than Nike Ajax which has guarded key cities and strategic areas of the Nation for the past three years. It is expected that the new missile will be in the hands of operational Nike batteries around the country in the near future.

Although longer, heavier, and more than double the diameter of Nike Ajax, the Hercules model will have extreme maneuverability at altitudes far in excess of those capable of being reached by Ajax. Its higher velocity will permit swifter interception of the most advanced types of aircraft, and its increased lethality will make Nike Hercules one of our effective weapons.

NEW NAVY ROCKET

The Navy has a new 5-inch, high-velocity aircraft rocket named Zuni. It was developed for the Navy's Bureau of Ordnance by the Naval Ordnance Test Station, China Lake, Calif.

(*Continued on p. 1018*)



Sky Steel

Aircraft design today is a challenge unequalled in any period of the past. The exacting requirements to produce a superior result have pushed metallurgy and metal working beyond traditional practice.

The designer less often selects from standards but rather proposes new shapes and new materials to produce results beyond traditional thinking.

Cameron's contribution to this era has been the development of an unusual forging process for large, intricate ferrous components. Elimination of welds, better grain structure, internal as well as external curvatures, and considerable machining economy are making these remarkable "Sky Steel" forgings more popular every month. For complete information write or call . . .

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Official Photo U. S. Navy

unique dual-role radar guidance system by Reeves INSTRUMENT CORPORATION

Developed for U. S. Navy Bureau of Ordnance

Twin Terrier Missile Launchers, shown in this official Navy photo on the after-deck of the USS Gyatt, give the world's first guided missile destroyer an atomic-age weapons system equal in range, accuracy and striking power to that usually associated with a 45,000-ton ship.

Key to this successful installation of the supersonic Terrier system in the close quarters of a destroyer is the unique new Reeves **combined** automatic missile radar guidance and fire control system, developed out of Reeves' experience with previous successful Terrier installation "firsts" in the cruiser USS Boston and in the battleship USS Mississippi.

While serving the dual role of automatic radar tracking and guidance for the Terriers, as well as fire control for the destroyer's 3″ and 5″ guns, this new Reeves system is compact (as shown by inset photo above), has great range and precision, and is capable of self-monitoring. It requires few operating personnel.

Here is yet another example of Reeves' close and highly successful association with the U.S. Navy and other branches of the Armed Forces in many of the military electronics projects that have been or will be recorded as dramatic "firsts" in their fields. Reeves research, engineering and unique precision manufacturing facilities are specifically geared to this pioneering tempo.

helps Navy's first guided missile destroyer pack a battleship's wallop

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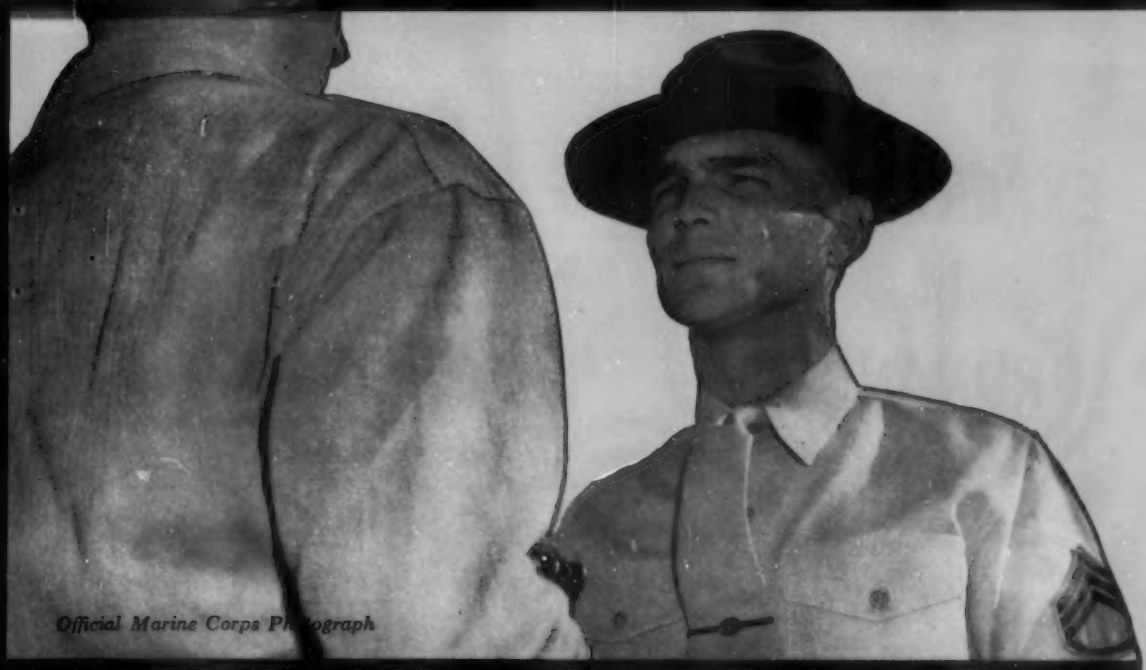


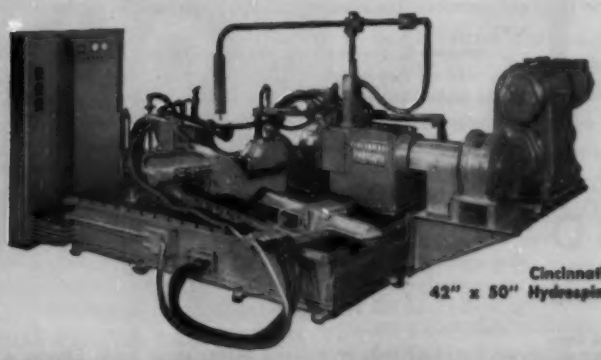
Official Marine Corps Photograph

This MAN Forms MEN

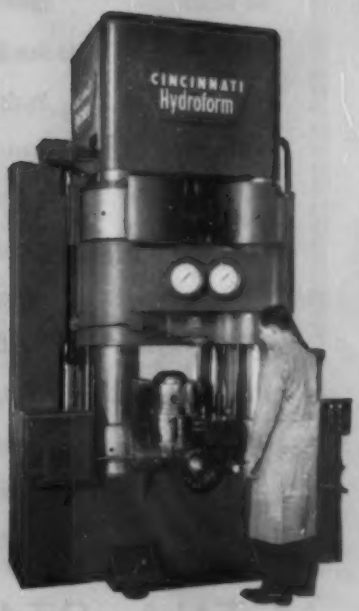
A Marine "D.I." (officially "Drill Instructor") guides each Marine through "boot camp" . . . shaping, strengthening, hardening, tempering the mettle that will enrich the greatest fighting tradition and *esprit de corps* in history.

These machines form metal . . . The Cincinnati Milling Machine Company's Hydroform® and Hydrospin®. In production on previously difficult-to-form aircraft, engine, missile and other components, they have greatly reduced vital development time . . . created savings of 50% and more in material, tooling and labor costs.

A Process Machinery Division field engineer will give you detailed information on applying Hydroforming and Hydrospinning to your metal forming jobs. Why not ask him to call?



Cincinnati 42" x 50" Hydrospin



Cincinnati® 19" Hydroform. Also built in 8", 12", 23", 26" and 32" sizes.

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Navy Yokes	Landing Mat Machines
15" H. C. Projectiles	Fork Lift Trucks
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Tank Turret Redesign

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New Developments (Contd.)

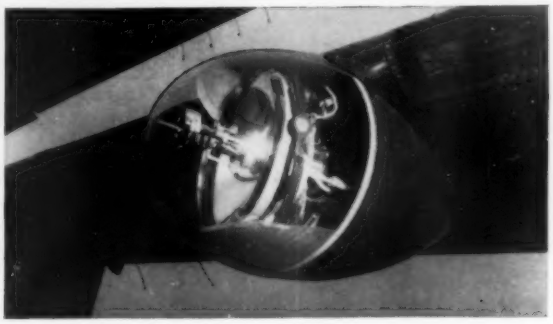
Zuni is a folding-fin, solid-propellant rocket to be used on fighter and attack-type aircraft and is designed for both air-to-ground and air-to-air attack.

As an air-to-ground weapon it will be highly effective against tanks, pillboxes, gun emplacements, trains, motor convoys, ammunition and fuel dumps, and small ships. As an air-to-air weapon, it will have a high potential against aircraft because of its high velocity and consequent short time to target. One Zuni is capable of bringing down a jet plane.

The new rocket has been approved for operational use in the fleet. It will replace the World War II high-velocity aircraft rocket in new high-performance aircraft. The new rocket has almost twice the velocity of the HVAR, and its folding fins permit a plane to carry four times the former number of rounds.

NEW AIRBORNE SEARCHLIGHT

A revolutionary new airborne searchlight has been developed by the Arma Division of American Bosch Arma Corporation at Roosevelt Field, Garden City, N. Y. Small, lightweight, and



Antisubmarine 130,000,000-candlepower searchlight.

almost as bright as the sun itself, the new carbon-arc lamp has a maximum light output of 130 million candlepower.

Carried into the night skies on the wings of Navy antisubmarine aircraft, the new light, known as the AN/AVQ-3, would illuminate enemy submarines lurking off our shores so that they could be bombed or torpedoed out of action.

The light can be directed by aircraft radar or operated by hand, and it can burn for a long time without "rest" periods.

NEW INVENTIONS NEEDED

Ideas of free-lance inventors are needed right away to help solve nine "blue-sky" problems which baffle the armed services, according to the National Inventors Council, U. S. Department of Commerce. The nine revolutionary ideas needed by the services are:

Nonmagnetic compass.—A device small enough to be carried by a man on foot which can determine true north independently of the earth's magnetic field. Better still, it should enable a man to determine his position accurately.

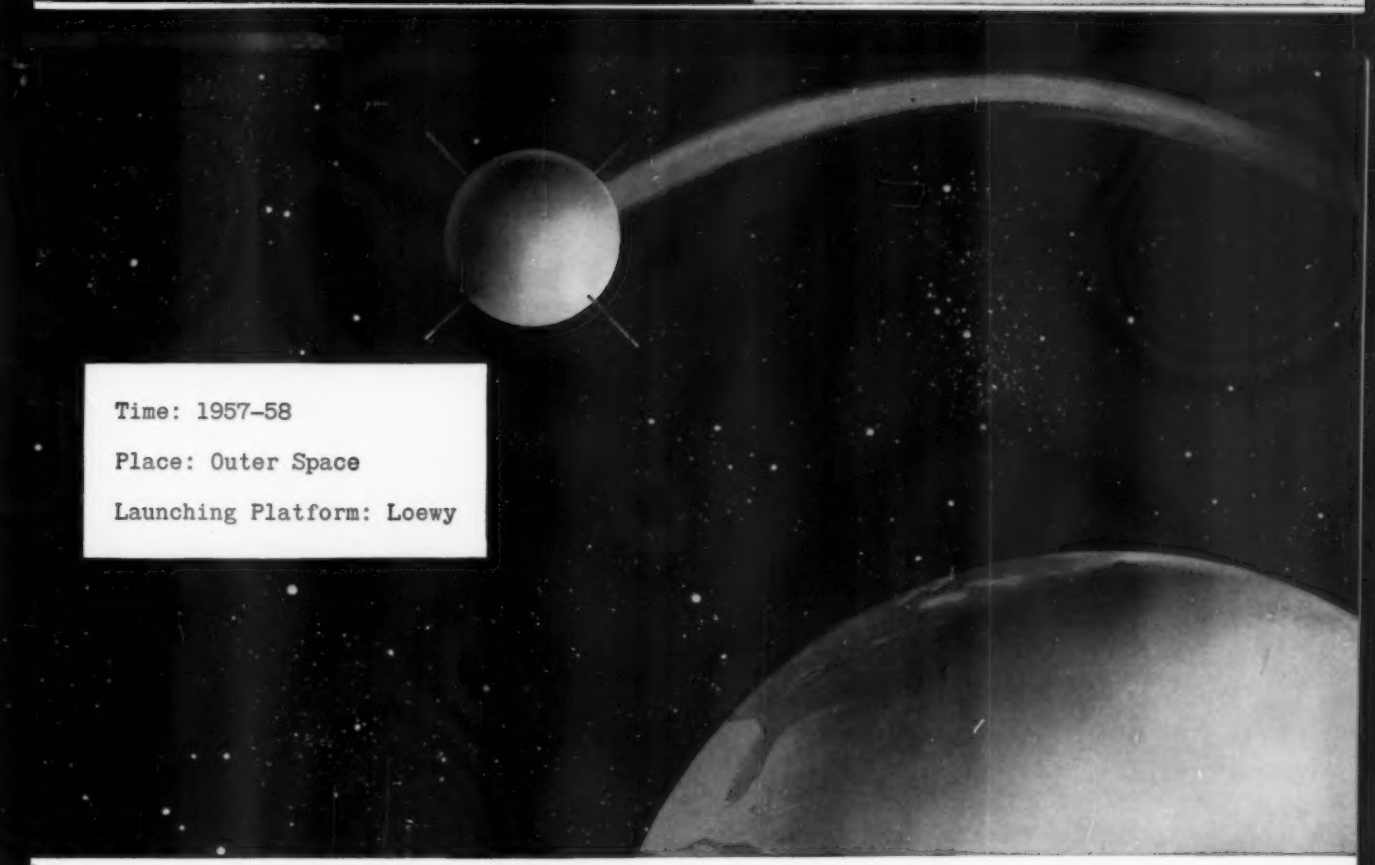
Explosive mine detector.—A method for locating explosives buried at shallow depths below the earth's surface. Present detectors locate the explosive's container or signal the presence of a hole in the ground.

Method for converting light into electrical energy.—An invention which will convert a small amount of light into enough electricity to operate electrical equipment. Far greater power output is needed than has as yet been supplied by solar batteries.

Snow track eraser.—A practical means of destroying the telltale tracks of men or vehicles across snow fields. Object is to restore original contour of snow field to avoid air detection.

Destructive ray or wave.—Equipment of usable size capable of producing death rays effective at 500 yards without excessive power input. Investigations so far indicate that a completely new approach is needed.

(*Continued on p. 1020*)



AROUND THE WORLD IN 90 MINUTES. Artist's conception of the first man-made satellite, which will circle the earth in 90 minutes as it hurtles through space 300 miles from us at a speed of more than 18,000 miles an hour.

Artist's conception of Vanguard rocket carrying earth's first man-made satellite as it is being launched.

Loewy-Hydropress builds earth satellite launching platform

Under Project Vanguard, the launching structure for the earth's first man-made satellite has been designed, built and installed by Loewy-Hydropress. This platform will be used for both testing and firing the huge 3-stage rocket and will measure its weight and pull during static firings. Loewy-Hydropress, under its subcontract with The Martin Company, Baltimore, prime contractor for the rocket, is in charge of complete stand instrumentation and support stand mechanisms, as well as of utilities and preliminary research, such as heat stress analysis.

The same talents that have successfully met the challenge of Vanguard are solving unprecedented problems in the Fleet Ballistics Missile Program, the Intercontinental Ballistics Program, and other major tactical missile operations. Also making a vital contribution to Project Vanguard is the Electronics and Instrumentation Division of Baldwin-Lima-Hamilton.

Loewy-Hydropress experience in missile launching systems, together with its engineering and complete fabricating facilities, is at your disposal. Take advantage of Loewy's exceptional background and wide range of creative skills. Write us today, Dept. H-5, for full information.

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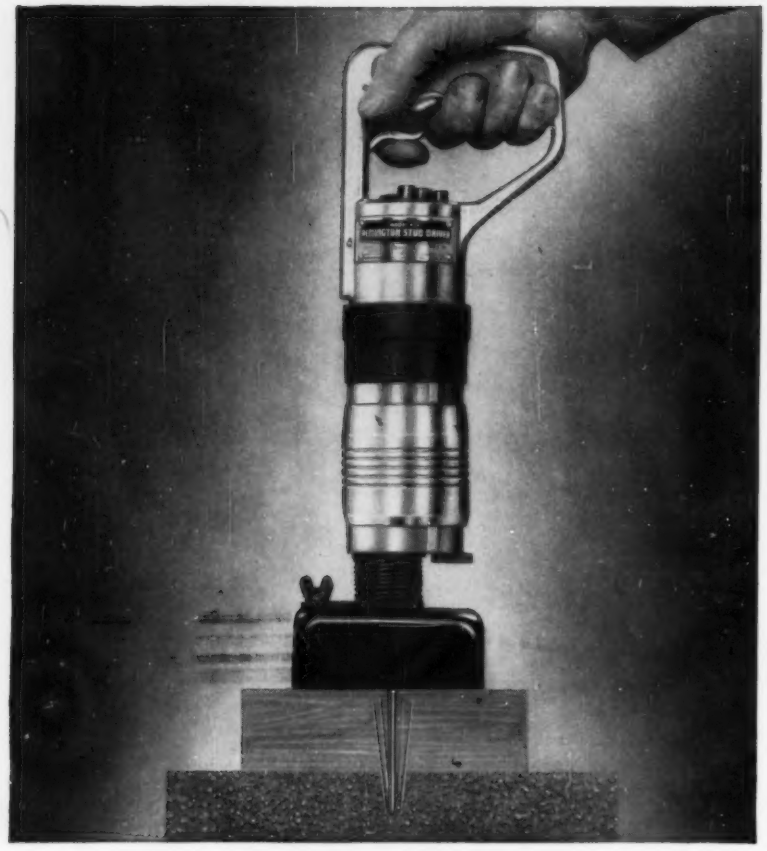

Just a squeeze sets the fastening stud in steel or concrete!

THAT'S HOW SIMPLE IT IS—a flex of the finger—to anchor fixtures securely with the Remington Stud Driver. Off goes the power load, the stud is anchored into steel or concrete—straight as an arrow. No predrilling or outside power source required!

You can set both ¼" and ⅜" diameter studs with the Remington Stud Driver—up to 6 studs per minute either size. There are 40 different styles and lengths of Remington Studs to choose from. With this *one* tool, you can take on *every* stud-fastening job—light, medium and heavy-duty—and save time and money on every one of them! Get full details by mailing coupon below.

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New Developments (Contd.)

Universal track.—A new method of traction for land vehicles for use on all types of terrain. Present steel tank tracks wreck paved roads.

Radical method for unloading ships.—New means of quickly discharging large quantities of military supplies from commercial or military vessels, either over the beach or at dockside.

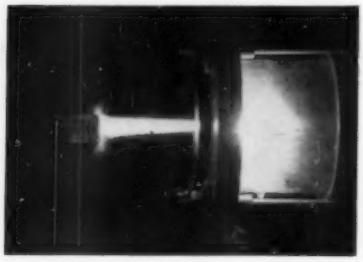
Vehicle blackout devices.—Inventions to mask the light, noise, and radiation from combat vehicles operated under cover of darkness.

New type of communication.—An ingenious new method of transmitting intelligence, nondetectable except by the desired receiver. The military is seeking a new principle which does not use electrical impulses, electromagnetic waves, or sound waves.

Complete lists of hundreds of technical problems affecting the national defense may be obtained by writing the National Inventors Council, U. S. Department of Commerce, Washington 25, D. C.

HIGH-TEMPERATURE ARC

Atomic vapor—the fourth state of matter, the substance of the stars—is being produced by the General Electric Company's Missile and Ordnance Systems Department in their Aërosciences Laboratory, in conjunction with University of Chicago scientists. Key instrument in producing this substance is a water-stabilized arc which is controlled, or stabilized, by a whirling blanket of water around the arc. The water forces the arc column to stay within prescribed limits and allows more and more current to flow across the arc points with correspondingly increased temperatures and higher velocities.



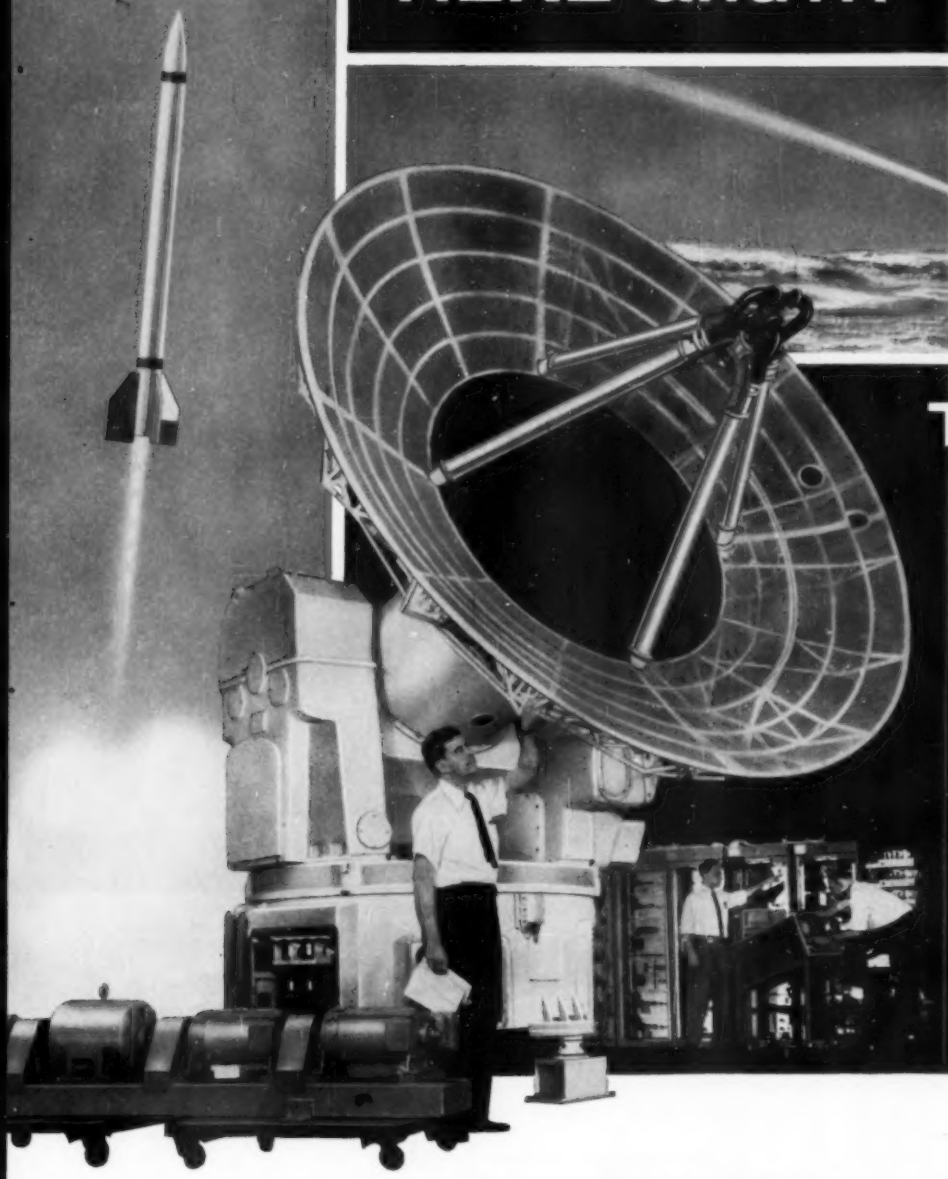
Fluid-stabilized arc in operation.

The new arc has allowed the creation of the highest technically useful temperatures yet achieved on a continuous basis. The highest verified temperatures measured thus far have been 25,660 degrees Fahrenheit. For comparison, the surface temperature of the sun is 11,260 degrees Fahrenheit. These temperatures are brought to bear on objects by a plasma stream, or jet, flowing at high velocities

(*Continued on p. 1023*)

What does it do between

HERE and...



THERE?

For the first time the behavior pattern of a free space Moving Target can be directly calibrated and immediately evaluated!

The proof of any guided missile is its performance. Not only is it necessary to provide accurate trajectory data in order to determine its effectiveness, but this must be made immediately available.

To meet both requirements is the purpose of the AN/FPS-16 instrumentation radar. This is the first radar developed specifically for Range Instrumentation. It has demonstrated its ability to track with accuracy in darkness, through clouds—under any atmospheric conditions—over extended ranges, and to yield data that can be reduced almost instantaneously to final form. This unit can also be assigned to plot performance of missile, satellite, drone and other free space moving targets.

In the past, this data has depended upon optical devices, triangulation systems with long base lines and precision limitations, modified radar equipment and data reduction methods often requiring months for computation. The immediate availability of data evaluation provided by the AN/FPS-16, now being built by RCA under cognizance of the Navy Bureau of Aeronautics for all services, is a great forward step in Range Instrumentation.

Defense Electronic Products

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Camden, N.J.

Trademark(s) ®

Only the men are flying

The fact is, men beat birds at their own game. Even when our feathered friends are grounded, we're aloft; flying ever higher, faster, safer, further. And, unbelievable as it may seem, more accurately.

Among the companies spearheading man's conquest of the sky are nine of the GPE Group. Their contributions are basic—technological bench marks such as—

• the only compass systems that *always* know where north is, whatever the plane does, wherever it goes: Kearfott's stable-platform gyro compasses;

• the only simulators to meet the need for on-the-ground training in supersonic flight: famous Link jet simulators;

• the only airborne navigation systems in operational use guiding planes automatically and with unprecedented accuracy — anywhere, in any weather: GPL Doppler autonavigators.

Inertial navigation, missile guidance, photoscience, and certain nuclear power applications, are some other phases of aviation in which GPE companies are deeply and jointly involved. And while many of the products of the GPE companies — particularly in the field of aviation—serve defense needs today, the important scientific advances they embody are "plowshares" for tomorrow.

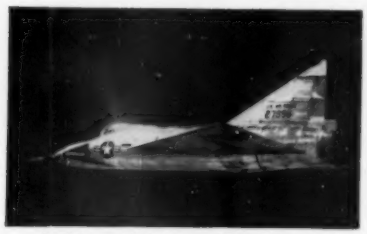
Aviation is but one industry in which GPE companies work. A brochure describing the activities of the group is available. More than a dozen basic industries are served by products resulting from GPE coordinated technologies and resources.

GENERAL PRECISION EQUIPMENT CORPORATION

PRINCIPAL PRODUCING COMPANIES • Askania Regulator • GPL • Graflex • Griscom-Russell
Hertner Electric • Kearfott • Librascope • Link Aviation • Pleasantville Instrument • Precision Technology • Shand and Jurs • Simplex Equipment • Strong Electric

man aloft

The pilot – before he set eyes on this jet, before he set hand to the actual controls – had already "flown" it. He learned how, on the ground, in a Link F-102 Simulator . . . one of more than a million fliers who have logged "Link time." Millions more will.



Military flight and fliers benefit immeasurably from the systems and equipments developed by GPL, Kearfott, Librascope and the other GPE companies working in aviation. Once these classified products are released for civilian use, everyone will enjoy their benefits.

The coordinated resources of the companies of the GPE Group, so effective in anticipating and meeting the needs of flight, serve with equal effectiveness other industries such as:

Automatic Controls and Instrumentation
Chemical and Petroleum
Marine
Motion Picture and Television
Paper, Printing and Textile
Power Generation and Conversion
Steel, Mining, Transportation

For brochure describing the work of the GPE Group, write to: GENERAL PRECISION EQUIPMENT CORPORATION, 92 Gold Street, New York 38, New York.

New Developments (Contd.)

from the arc through a nozzle, or orifice, in one of the electrodes. By using air-stabilized arcs, now under development, velocities of 10,000 feet a second can be achieved; with the water-stabilized arc, 4,000 feet a second are being reached.

"BRAIN" FOR ORDNANCE

The world's largest electronic brain—a $4.1-million electronic data-processing system known as Bizmac and built by the Radio Corporation of America—has been installed at the Army Ordnance Tank-Automotive Command headquarters, Detroit, Mich.

The system has reduced months of paper work to minutes of push-button operation. It keeps track of more than 100 million facts about the Army's vast inventory of tank and automotive spare parts throughout the world—everything from nuts and bolts to entire engines. Bizmac maintains up-to-the minute information about what supplies are on hand, how fast they are being used, what has to be ordered and in what quantity.

NUCLEAR ROCKET

The Air Force has disclosed that three of its fighter-interceptor types are being trained in the use of the air-to-air nuclear rocket officially designated as the "MB-1." It has been reported that the rocket will destroy a whole formation of planes scattered as much as a mile apart.

The new weapon is light enough for a pair to be carried by the F-89J Scorpion—the new J version having been created for that purpose.

A pair also is mounted on the supersonic F-101B, an all-weather type operating in fog, day, or night. It also is in the new supersonic F-106.

114-ROCKET SALVO

A North American F-100C Super Sabre of the Air Research and Development Command's Air Force Armament Center recently fired 114 aërial rockets simultaneously at a tank located on one of the ranges at Eglin Air Force Base, Fla. This was the most rockets ever fired at one time from a jet aircraft.

The rocket firings were made in conjunction with the testing of the LAU-3/A rocket launcher, a new, low-cost launcher developed by Century Engineers, Inc., for the U. S. Navy. Now in operational use in the Navy, a modified version of the launcher is undergoing evaluation testing at the Air Force Armament Center before going into the Air Force inventory.

The F-100 fighter-bomber is capable of carrying six of these launchers under its wings and of firing them simultaneously or in any pattern desired. Each launcher contains nineteen 2.75-inch folding-fin aircraft rockets.

HIGH-ENERGY FUEL

Ground was broken recently for a $38-million high-energy fuel plant at Muskogee, Okla. The plant, to be built and operated by the Callery Chemical Company, is designed to produce a new type of fuel developed under project "ZIP." When completed it will be the world's largest high-energy fuel plant.

Characteristics of the new "exotic" fuel are classified, but the Navy revealed that the synthetic fuel, known as HiCal, is expected to power jet aircraft and missiles to unprecedented peaks of performance and efficiency.

Gallon for gallon, HiCal will multiply the range of a jet plane or missile and permit flying at altitudes substantially higher than any present-day aircraft now can reach without rocket propulsion.

NEW DROP PLATFORM

An aërial drop platform is giving U. S. paratroopers new mobility and firepower. They now are able to go into battle with tanks, trucks, artillery, and other heavy equipment parachuted to them in undamaged, ready-to-go fashion on air rafts

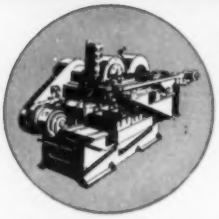
Aërial drop platform.

whose fall is cushioned by huge bellows-like rubber cylinders.

Produced by Brooks & Perkins, Inc., of Detroit, under contract with the Wright Air Development Center, Dayton, Ohio, the air-delivery platform is made of lightweight magnesium and equipped with a series of barrel-shaped rubber bags extending along its underside. The cylindrical bags are produced by the Aviation Products Division of Goodyear Tire & Rubber Company.

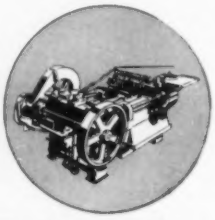
Carried on a roller-type conveyor in an airplane's cargo compartment, a loaded raft is ejected from the plane and lowered to the ground by parachute. During descent, plywood doors restraining collapsed air bags spring open to permit the bags to inflate in time to cushion the fall of the platform and prevent damage when it reaches the ground.

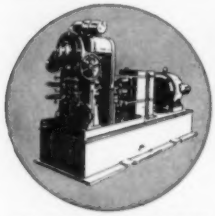
FIVE KINDS OF MASS PRODUCTION METALWORKING MACHINERY by Waterbury Farrel



COLD PROCESS BOLT & NUT MACHINERY —Headers (all types) • Rivet Machinery Trimmers • Thread Rolling Machines Slotters • Nut Formers and Tappers, etc.

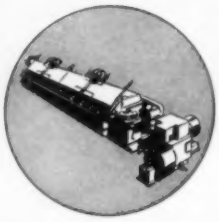
POWER PRESSES — Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines • Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc.

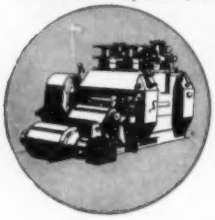




MILL MACHINERY — Rolling Mills: Strip, Rod, Tube, Wire Flattening, (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc.

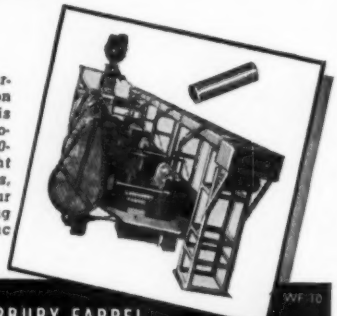
WIRE MILL EQUIPMENT — Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers • Swagers • Bull Blocks • String-up Machines • Spoolers, etc.





SPECIAL MACHINERY — Sendzimir Mills • Small Arm Ammunition Machines • Thread Rolling Machines For Shells • Collapsible Tube Machines • Coining Mills, etc.

HERE'S A SAMPLE of Waterbury-Farrel mass production equipment in action. This complete WF automatic production unit combines a 40-ton double-acting, upright blanking and cupping press, a conveyor feed and four 7-station horizontal drawing presses to draw 340 zinc shells per minute.



WF-10

WATERBURY FARREL FOUNDRY & MACHINE CO.
WATERBURY, CONN.
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ARMAMENT ELECTRONICS

GUNNERY SYSTEM SIMULATOR

W. H. MacWilliams, Jr.

Excerpted from the Bell Laboratories Record, March 1957

THIS article describes what is believed to be the first working application of transistors. The early point-contact transistors (Type-A), announced by Bell Telephone Laboratories in 1948, were used early in 1949 to perform a circuit function essential to a laboratory simulated warfare computer developed in the course of a contract with the Navy Bureau of Ordnance. The computer was called the Gunnery System Simulator and was used to simulate the action of a warship's guns in fending off an enemy air attack.

A warship contains many groups of guns and many controlling radars. Each gun group must have a radar to track its target and a computer to predict the target's future behavior and calculate where the guns must fire for their projectiles to burst near the target. In practice, more than one group of guns can be fired from orders calculated by the same computer. To simplify this description, however, the combination of radar, computer, and group of gun mounts will here be considered an indivisible fire unit and will be called a "director" in this article.

Since each of a warship's directors can fire at only one target at a time, the ship must divide its directors among the attacking airplanes, sometimes assigning more than one to the same plane. After a director has shot down a plane, it must be reassigned immediately to another target.

The task of the Laboratories was to assist the officer who assigns directors to targets by developing equipment to compute and display information to help him make his decisions and by studying various logics for carrying out the defense. It is clear that a seagoing test should only be the last phase of a program, because of its overriding expense and limited usefulness.

Accordingly, it was decided to build a simulated-warfare computer, the Gunnery System Simulator, which would enable arbitrary mock attacks to be flown against human beings equipped with laboratory-constructed aids. The simulator was designed to represent the statistical nature of gunfire lethality and to keep score of the results. A given attack could be flown as often as required to obtain statistical reliability, and the aids could be tested with different observers under the same set of conditions.

The man being tested was at a console where he assigned directors to targets on the basis of information showing the threats of the targets and the present state of the directors. The behavior of future high-speed aircraft could be represented as desired. The simulator was thus the laboratory equivalent of being able to test proposed aids in extended tactical fleet exercises with gunfire, against targets expected to be available only in the future, and at comparatively low expense.

THE transistor gating matrix was developed to perform a function required for the Gunnery System Simulator, connected with computing the lethal effect of individual projectiles fired from simulated guns against their simulated targets. The matrix was required to channel pulses corresponding to individual projectiles into appropriate circuits for computing kill probability.

(*Continued on p. 1026*)

Systems engineering–38th parallel style

Here's the challenge we received from the Korean Civil Assistance Command and the U. S. Army Signal Corps:

Build a telephone communications system to their specifications that will function over mountainous terrain. Cost to be within reasonable limits . . . upkeep minimum . . . equipments compatible with the experience and background of the population.

The answer is the system now being installed in South Korea.

Manually operated telephones, central offices and PBX switchboards, suited to a civilian population unfamiliar with dial methods.

Wire lines for basic country-wide linkage, augmented with many channels of *Carrier*, wherever estimated traffic warrants it.

And—delivery on schedule.

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***Dow Corning 6* continues to protect long after other lubricants fail. Water repellent and extremely resistant to oxidation, it will not gum up, thin-out or stiffen with age, and has no apparent effect on explosives.**

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DEPT. 8317a

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DOW CORNING CORPORATION Midland, Michigan

Armament Electronics (Contd.)

These circuits were called "p-computers," since "p" is the symbol used to represent the probability that a single shot would knock down the target. The p-computers permitted calculation of the number of targets shot down.

Broadly speaking, the simulator resembles a pinball machine. In such a machine a ball bounces off the pins set in an array on the playing surface, and there is a certain chance that the ball will fall into any particular hole. The array of pins is analogous to the probabilistic portion of the simulator, and the array of lights is analogous to the score-keeping portion. In this sense, the transitor gating matrix serves as a connecting link between the array of pins and the scoreboard.

The assignment of directors to targets is represented by the target-by-director switch, which was controlled either by an operator or automatically. All the directors could be used simultaneously. Of course, it was not known in advance which directors would be assigned to a particular target.

Before a series of simulated attacks it was stipulated that each target be associated with a p-computer appropriate to its flight path. This was done by manually presetting the target-by-p-computer switch. In this switch, the target coördinate is depressed so that its output at any instant represents the desired connections of directors to p-computers.

From these control signals, the director-by-p-computer matrix (the transistor gating matrix) receives low-level binary (on or off) pulses representing the projectiles, amplifies them, and channels them into the proper p-computer circuits. The director circuits were so designed that only one of them could send a pulse to the matrix at any instant, and thus a pulse in a p-computer could be identified with the director that initiated it.

FUTURE DEMANDS ON COMPONENT DESIGN

Capt. W. I. Bull, U.S.N.

Excerpted from the Bureau of Ships Journal, April 1957

SUBSTANTIAL advance in the component art and the materials going into components are a need that will increase in the next few years. Today, military demands on the electronic industry are so great that their impact is one of the major stimuli in the advancement of the state of the art.

Too frequently electronic components are marginal. Great advances must be made in the next few years to keep pace with military and industrial planned programs.

Also, something must be done about the inadequate room abroad modern ships and aircraft for all the electronic equipment required. One solution might be the use of less electronic equipment. Unfortunately, that cannot be done—the functions the equipment must perform are essential to the ship and the aircraft.

Temperature is the most serious problem affecting efficiency today. As is well known, when electronic parts with large losses are used, the losses usually result in heat. When a lot of these heat-generating devices are packed in a small space, the over-all temperature goes up. That is, environment is created with an ambient temperature that is intolerable.

The need for parts to operate at higher temperatures outweighs the requirements for ability to withstand greater shock, vibration, humidity, and so forth, important as these are.

ALTHOUGH the ability to withstand high temperatures affects reliability, a discussion of relativity at the temperatures to be faced in the future is not yet possible. Some real degree of performance at such temperatures must first be obtained.

For example, today, a temperature range of minus 55 degrees centigrade to plus 125 degrees centigrade is the range over which all parts can be expected to operate continually at their rated values. The state of the art would indicate that this performance is obtainable in high-quality parts; but even at these temperatures some parts, if they meet the requirement, do so marginally.

For example, rectifier performance, with the exception of silicon, is marginal at the high temperatures, and the supply of silicon rectifiers is still quite limited.

Not far ahead a need can be seen for temperatures down to minus 65 degrees centigrade and up to 200 degrees centigrade.

A look beyond that—and not very far beyond—shows the temperature requirements still mounting.

Component engineers of the Bureau of Ships, in a recent study of temperature characteristics of present-day electronic parts, found that less than 25 per cent of them would meet the 200-degree-centigrade limit. Included in the 25 per cent were many types of components that are barely out of the laboratory development stage.

Development of new electronic component parts for new applications is vital to the success of meeting operational requirements.

Of interest for the future in the effort to keep self-generated heat down is the semiconductor device. Unfortunately, semiconductors themselves have a temperature-limitation problem. The use of silicon appears to be the answer to the heat problem here.

Even if the temperature limitations of the semiconductor are solved, a full line of parts to exploit the full advantages of the transistor will be needed. The new

Logistics Jackpot

Steel girders—wooden beams—cable and wire reels—railroad ties and track—delicate electronic equipment—these are typical C-123 loads on any logistics mission.

Jet engines, food, medicine and hospital supplies by the ton—these make up the bulk of C-123 cargoes.

These versatile transports can move entire divisions—at the rate of up to sixty men or eight tons of cargo per plane. Big loads do not mean hard surfaced runways—the C-123's assault transport characteristics turn narrow clearings and furrowed fields into landing areas.

Reliability—versatility—performance . . . these C-123 qualities are typical of the Fairchild design and production philosophy.

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parts will be scaled-down sizes of parts comparable to the size of transistors rather than to that of subminiature electron tubes.

For capacitors, the main differences between the types needed for transistor circuits and those now used for electron tube circuits will be in the capacitance values required and the lower working voltage range (5 to 50 volts direct current) required for the transistor circuit types.

INDUCTOR characteristics required for use in transistor circuits will range in inductance value from 1 millihenry to 100 henries with 10 to 20 per cent tolerance. Magnetic saturation effects will put some limit on the degree of inductor miniaturization possible. Minimum direct-current resistance requirements for the inductor windings may impose further limitations since the resistivity of very fine wire required for compact windings is high.

Because production of small-sized inductors will cause problems associated with the mechanical fragility of fine copper wire, some development work may be found necessary to increase the wire's tensile strength. It may even be necessary to investigate and develop inductor winding fabrication means other than by wire; for example, by photographic etching.

Different transformer types are required, and most of the remarks that apply to inductors also apply to transformers as well.

In general, transistors will require the same types of resistors as those used for electron tube circuits, except that the types required will be smaller. Also, potentiometers will be needed that will have low wattage with voltage ratings of fifty or less.

The small sizes of transistors and comparable sizes of parts (when such parts become available) will lead to "transistorized" packaged subassemblies for use in military electronic equipment that are fabricated by mechanized or completely automatic means.

The Navy favors a modular and submodular type of construction because it will make possible progressive changes in equipments short of installing completely new equipment. High installation costs make this type of construction very desirable because the installation cost of a new equipment could equal the cost of the equipment itself.

Military and industrial operating environments are placing a demand on component parts that at first glance seems totally unreasonable and unobtainable, but the solutions to the problems, particularly the temperature problem, are needed badly and should be attained. However, they cannot be reached by any one segment of the industry. There must be coöperative effort.

Jet engine exhaust deflector manufactured by All American Engineering Company showing Du Pont Aircraft Rivets used in its assembly.

How Du Pont Aircraft Rivets solve high-temperature fastening problems

Like many other companies now doing research and development work in the higher temperature range, the All American Engineering Company of Wilmington, Delaware, uses Du Pont Aircraft Rivets when blind fastening is required.

The A-286 Superalloy Rivet retains high shear and tensile strength even when subjected to extreme vibration at 1200°F., as it is in this jet engine exhaust deflector. These rivets must withstand continuous load reversal and stress cycles without failure.

Here strength is vital. But, as a bonus, All American gets the extra speed and simplification of assembly provided by Du Pont Aircraft Rivets. Working only from the head side, the operator expands the rivets with an inexpensive electrically heated Du Pont riveting iron or similar tool. Parts are locked solidly and permanently together.

For complete information and specifications, write E. I. du Pont de Nemours & Co. (Inc.), Explosives Dept., Wilmington 98, Del.

• • •

Du Pont Aircraft Rivets for high-temperature applications are manufactured with either modified brazier or 100° countersunk heads in A-286 Superalloy and nickel. Currently available in three nominal diameters, 1/8", 5/32", 3/16", and a wide variety of lengths.

DU PONT AIRCRAFT BLIND EXPANSION RIVETS

DU PONT

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A Product of Du Pont Research

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

FICo engineers and produces the guidance for the Redstone Missile.
U.S. Army Photo

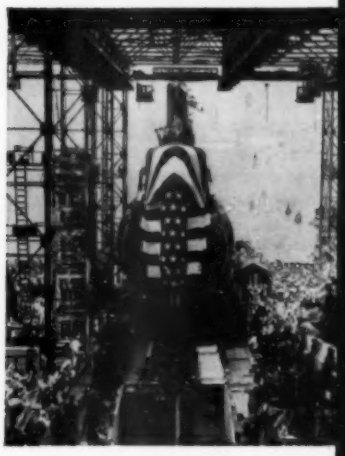
FICo COMPUTER AND CONTROL SYSTEMS

- For Weapons Control
- For Processing of Data
- For Special Purpose Computer and Control Applications

Ford Instrument Company develops and produces the most modern of special purpose computer and control systems—for missile, airborne, shipborne, land-based, and nuclear applications—for *government and industry.*

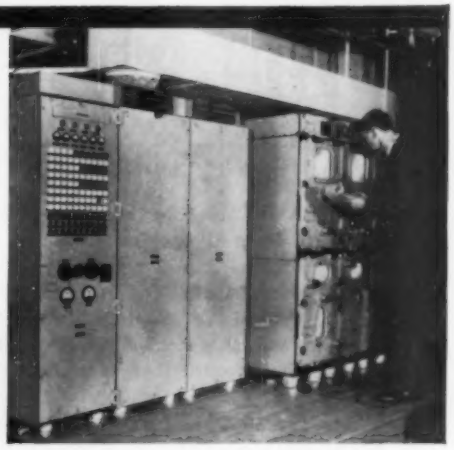
FICo is one of the foremost organizations in the United States working in the field of automatic control. Hundreds of engineers and extended precision mass production facilities enable FICo to handle complete systems contracts from start to finish.

FICo navigational equipment goes into a wide range of aircraft.
U.S. Air Force Photo



FICo controls are used in the atomic submarine program. FICo is also working toward development of the closed-cycle gas-cooled reactor.
U.S. Navy Photo

FICo research and design led to improved safety and arming device for Army atomic cannon.
U.S. Army Photo



FICo analog and digital computers can be readily developed and produced—using modular techniques—for special purpose applications.

FICo launching and control order computers are used for Navy A-A missiles.—*U.S. Navy Photo*

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MATERIALS PROGRESS

George S. Brady

Rubber and the Stockpile.—As a corollary of the industry-government meetings on the subject of natural rubber which took place at the time of the closing of the Suez Canal, some new concepts regarding the entire stockpile program have appeared. Discussion has centered on rubber, but only as an example. The questioning also concerns manganese and some other metals, vegetable oils, tannins, mica, and other materials. It may bring a "new look" at this phase of defense planning.

There seems to be no dispute with the fundamental idea that ample reserves of strategic imported materials which are necessary for the production of military supplies should be accumulated, though it has been strongly expressed that these reserves could be carried more effectively and at much lower cost as industry stocks by the payment of bonuses for all stocks carried over and above normal industry stocks.

It was pointed out that the rubber stockpile, valued at $825,000,000, is costing taxpayers $38,000,000 a year for maintenance alone, excluding interest on investment and large overhead costs which are absorbed in other government costs but which in industry would be charged directly against the material.

However, it is the great shifting in strategic importance of these materials because of changes in material usages, and because of new production by synthesis, that is causing most concern about the nature of the present stocks built on the standards of a decade ago.

In the case of rubber, which requires periodic turnover, it is claimed by some that the present stockpile content of below-grade rubber is excessive and far above any quantity that would have been permitted to accumulate under direct industry supervision. However, this is of secondary importance, and actually is a part of the policy problem which comes within the jurisdiction of Congress rather than stockpile operation.

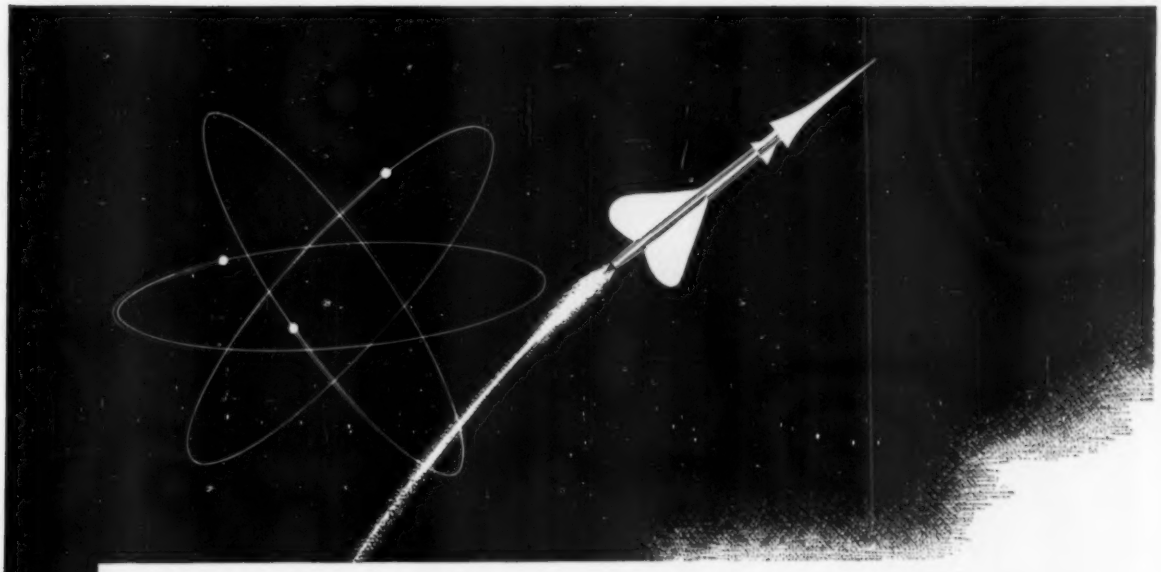
The chairman of the board of one of the important rubber companies possibly has gone furthest in the public discussion by urging that the Government "relieve taxpayers of the heavy costs of storage of rubber by immediate disposal of excess quantities and planning for eventual complete liquidation of the stockpile."

According to his estimate, our present stockpile of rubber is enough for a 7-year emergency at the present proportional usage of natural rubber, and our need for natural rubber is declining rapidly. The newer types of synthetic rubbers are equal and for some uses superior to natural rubber. Polyisoprene is expected to be completely equivalent to natural rubber, with ample supplies of raw materials available within the United States.

Manganese and Domestic Ores.—When stockpiling was first discussed in the Planning Branch of the Office of the Assistant Secretary of War, later to become the Munitions Board, a Southern industrialist who was then a Reserve Ordnance officer proposed that, instead of forming huge stockpiles of imported manganese ore, most of the funds should be used for continued research on methods for the utilization of the superabundant domestic low-grade ores.

Since World War II much money has gone into the purchase of domestic ores for stockpile, but these ores have been concentrated at premium prices by ancient metallurgical methods. With limited funds the Bureau of Mines has done some good work on new methods, but only now are new electrochemical processes being adopted to recover manganese from low-grade domestic ores.

(*Continued on p. 1032*)



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Materials Progress (Contd.)

One of the processes, operated at a pilot-plant of *Udy Metallurgical & Chemical Processes, Ltd.*, at Niagara Falls, claims to be able to obtain 7 tons of ferromanganese and 7 tons of ingot iron from 50 tons of 12 per cent Mn, 18 per cent Fe low-grade ore. The ore is ground and fed through a kiln and reduced with carbon in an electric furnace to separate out the iron and phosphorus.

The resultant slag is equivalent to high-grade ore. Later electric-furnace treatment with quartzite and carbon produces ferromanganese silicon, with another step to yield various commercial grades of ferromanganese.

Diamond Substitutes.—Industrial diamonds have been stockpiled at high expense because of their former great strategic importance for lapping and for drilling through hard materials.

But refractory hard metals have been able to replace industrial diamonds for many uses, and machines have been developed for grinding and drilling through hard materials by electronic and sonic methods more rapidly than can be done with diamonds. Now, General Electric Laboratories have announced a new form of boron nitride equal in hardness to the diamond and capable of scratching the diamond.

The new boron nitride, which was formerly produced only as a light, white powder, is in the form of tiny brown to dark red or black crystals with a cubic structure of the same crystal pattern as that of the diamond but with larger atomic spacing and with a density of 3.45 compared with the 3.52 of the diamond.

The boron atom has three outer electrons, one less than carbon, and the nitrogen atom has five outer electrons, one more than carbon. In combination in the crystal they give a result like combining two carbon atoms.

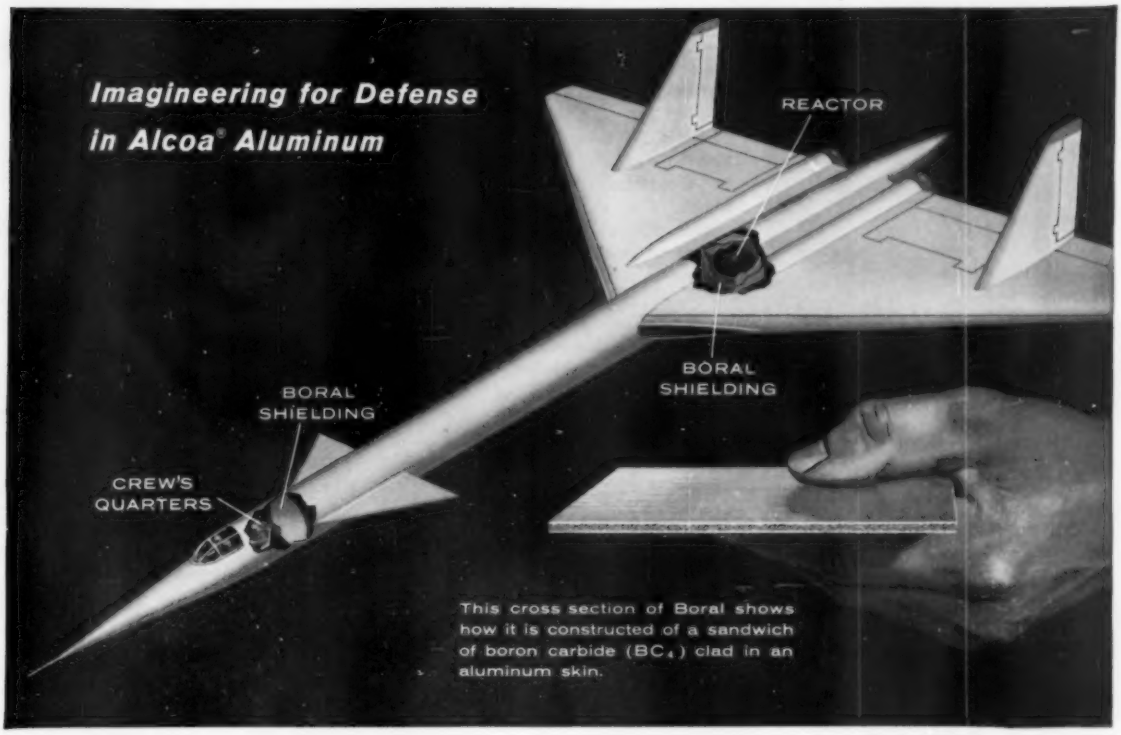
The present product is impure, but it is expected that crystals which approach the chemically pure material (43.6 per cent B, 56.4 per cent N) will be white or transparent. The material, named Borazon, is made in the new diamond-making press at a pressure of 1,000,000 pounds per square inch at a temperature of 3,000 degrees Fahrenheit.

Lapping tests have shown that it will polish hard materials at the same rate as the diamond. An advantage over the diamond is that it does not disintegrate at high temperatures.

New developments that have piled up at an amazing geometric rate in the past decade have made the original bases for judgment of a stockpile quite unrealistic in view of the conditions of today. Progressive changes have been made in policy during this period, but there are many who believe that the vast research programs, synthesis of materials, new sources of materials, and greatly improved defense of overseas supply lines have made an intensive "new look" a vital necessity.

Growth of Plastics.—The *Society of the Plastics Industry* estimates that the 1957 consumption of plastic materials will be 2,160,000 tons. This is based on a judgment that this year's rise will be only around 5 per cent, whereas the increase of 1956 over 1955 was 10 per cent. This is hardly a "leveling off" since consumption has increased to four times the volume of a decade ago in spite of some annual drops. Past growth has been greatest in vinyls, polyethylenes, and styrenes, but polyesters now have a big forward look although at present they constitute only a small part of the market.

New Globe Valve.—The *Walworth Company* now has an all-plastic Y-globe valve that is only one-sixth the weight of an equivalent brass or steel valve. It is designed for the piping of acids, alkalies, salt solutions, and corrosive chemicals, and is fully capable of replacing costly strategic-alloy valves for uses where the pressure is not above 150 pounds per square inch at 75 degrees Fahrenheit. Available now for 1-inch pipe only, the plastic valve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This cross section of Boral shows how it is constructed of a sandwich of boron carbide (BC_4) clad in an aluminum skin.

New Alcoa Boral stops neutrons 100 times better than concrete

The high neutron density from the reactor represents a very real danger to the crew of an atom-powered plane. Since it is impossible to get very far away from the source of the radiation, effective shielding must be used to block neutrons. Yet shielding is either very bulky and heavy, as in the case of dense concrete, or heavy and expensive, as in the case of lead.

A lightweight neutron shielding material developed by the Atomic Energy Commission may prove to be an effective solution to the problem. It is known as Boral from its principal ingredients, boron carbide and aluminum. Boral has 100 times the shielding effectiveness of dense concrete. A plate only ¼ in. thick stops more high-speed neutrons than two feet of solid concrete.

In response to AEC's invitation to commercial producers, Alcoa has developed a fabricating procedure that provides Boral plate and sheet in the largest sizes ever offered. It is made in thicknesses of ⅛ in. and ¼ in.; sizes 48 in. x 120 in. and 36 in. x 96 in.; annealed or "as-fabricated" tempers.

While Boral is ideal for mobile reactors such as those used in the Nautilus or in aircraft, it can be used anywhere that space and weight limitations are critical. It is already in use or planned for atomic power and research reactors of many types. It makes possible far more compact and workable designs.

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Materials Progress (Contd.)

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Plastic Wheels.—Lightness, strength, lowered cost, and durability are obtained by substituting plastics for metal in the wheels of a new *Sears, Roebuck* lawnmower. The wheel frame and spokes are made from one piece of high-impact polystyrene, injection molded around a nylon tube which serves as the bearing, requiring no oiling because of its self-lubricating quality. The nylon tube has a wall thickness of only 1/16-inch, but its high melting point permits molding of the styrene around it without distortion.

Canvas Preservative.—To find the best method of treating canvas and other cotton fabrics to protect against mildew and severe weather exposure, the *Department of Agriculture*, working on a research project with the *Canvas Products Association*, has come up with a recommendation for the use of copper-8-quinolinolate in a 6 per cent urea-formaldehyde resin solution. It has also been found that best results are obtained when the cotton is partly acetylated and vat-dyed.

Chemical Resistant Hose.—The *Mic-Lin Company*, Maple Shade, N. J., has a new chemical-resistant hose that will withstand sustained operating pressures to 4,000 pounds per square inch at temperatures to 500 degrees Fahrenheit and will remain flexible at temperatures as low as minus 100 degrees Fahrenheit. It consists of a Teflon liner encased in stainless-steel wire braid. Fittings are of stainless steel permanently locked to the hose, which may be in lengths to 50 feet. There are 8 sizes, from 3/16 to 1 1/8-inch in diameter.

Titanium Plating.—The *Missouri School of Mines*, working with the *Wright Air Development Center*, has developed a method of plating an adhesive coating of titanium metal on low-carbon steel. A bath of sodium chloride containing titanium-oxygen alloy is used. The hardness of the coating depends upon the oxygen content of the alloy.

To obtain a coating of 0.002-inch of titanium, a bath of 90 per cent fused sodium chloride and 10 per cent titanium-oxygen alloy is employed at a temperature of 1,832 degrees Fahrenheit. If the carbon content of the steel is above 0.020 per cent, it is difficult to obtain a good coating because of the formation of titanium carbides which prevent diffusion of the titanium in the steel.

Aluminum Boats.—Engineers of the *Aluminum Company of America* estimate that one out of every three pleasure boats is now made of aluminum and that seventy-five per cent of all pleasure boats now use aluminum for hardware, trim, and accessories. It is estimated that in 1957 more than 16,000,000 pounds of aluminum will be used in the manufacture of pleasure boats, plus another 22,000,000 pounds in outboard motors. Reduction in weight is one of the features, but ease of maintenance is an outstanding characteristic. The Navy, too, is using more aluminum. More than 2 million pounds of this metal is in the new U.S.S. RANGER, a 59,900-ton FORRESTAL-class carrier. This ship has 228,000 more pounds of aluminum than in the previous ships of this class.

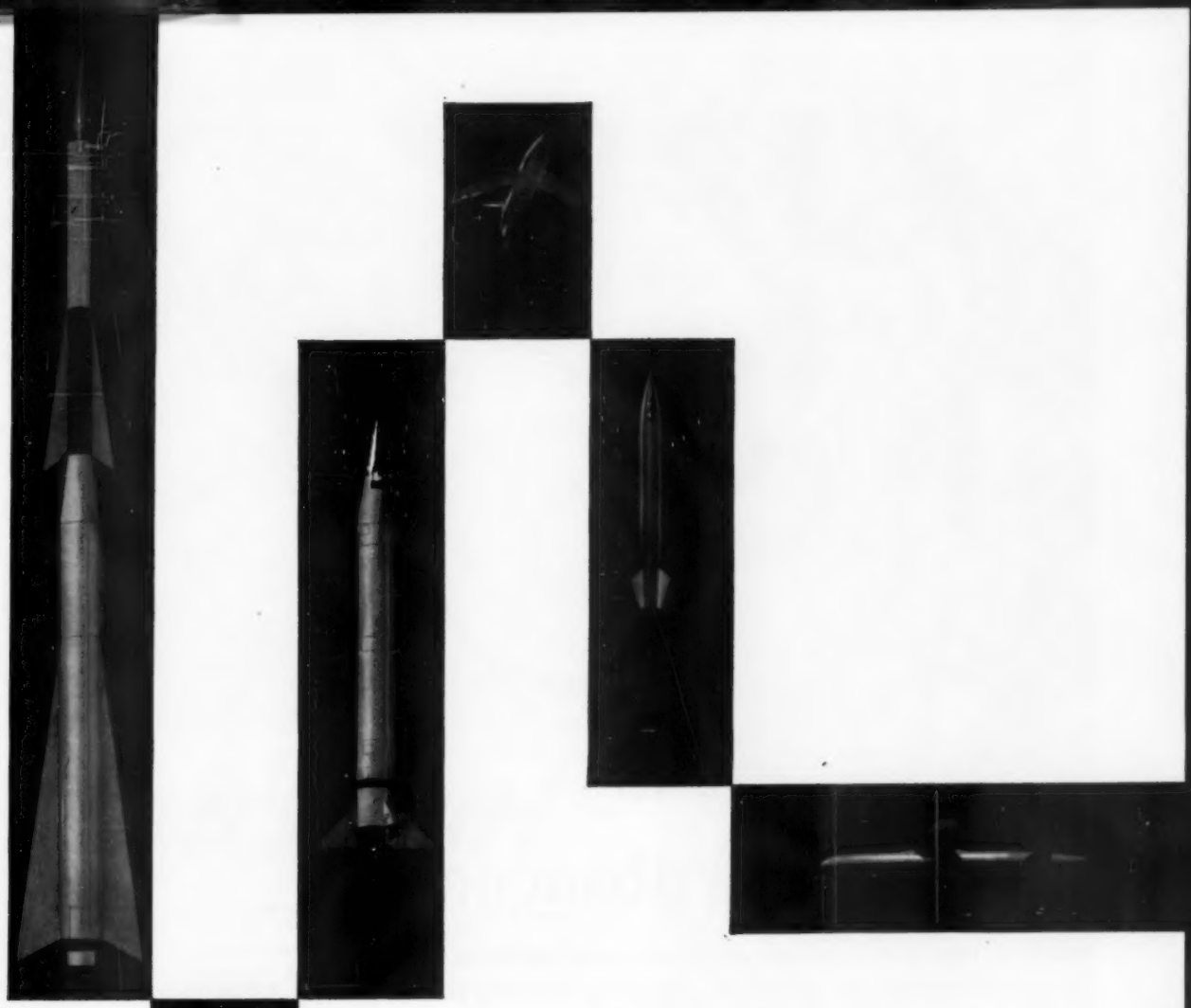
Aluminum Gondola Cars.—For its bauxite mining operation on the Island of Jamaica, the *Kaiser Aluminum & Chemical Corporation* is now using all-welded aluminum gondola cars. The cars, built by the *Magor Car Corporation*, have standard steel trucks, but the aluminum body permits a 14-ton per car increased payload over that of conventional steel gondola cars.

Lightweight Passenger Car.—Not all weight-saving in transportation equipment is with aluminum, however. The *Budd Company*, Philadelphia, Pa., has designed an 88-passenger railway car with a weight of only 595 pounds per passenger, making it the lightest passenger car ever produced in this country. It has an all-stainless steel structure, and the fittings, including seats, lighting fixtures, stairwells, and lavatory fittings, are of reënforced plastic. The lightweight seat cushions are of vinyl foam.

New Cargo Carriers.—Another type of construction designed for light weight is in the new Convert-a-frate refrigerated cargo carriers developed by the *Rock Island Lines*, Chicago, Ill., for highway trailer and railway flatcar use. These carriers measure 17 by 8 by 8 feet and are intended for shipping meats and other food products refrigerated with dry ice. The sides and roof are single sections of 5¾-inch balsa cores faced with ⅛-inch reënforced plastic skins. The floor is a 2¾-inch balsa core covered on top with plywood and surfaced top and bottom with reënforced plastic. The joints are cemented with an epoxy-resin adhesive, with no mechanical fastenings. The carriers are strong and rigid, and loads up to 14,000 pounds can be suspended from the ceiling.

Nylon Extrusion Powders.—The *Allied Chemical & Dye Corporation*, New York, N. Y., has a new nylon extrusion powder produced from polycaprolactam that is characterized by a high molten viscosity which eliminates voids and reduces shrinkage in thick sections of extrusions. The powder, designated Plaskon Nylon 820, is also available in a heat-stabilized form for insulating wire.

Another new nylon extrusion powder, produced by *E. I. du Pont de Nemours &*



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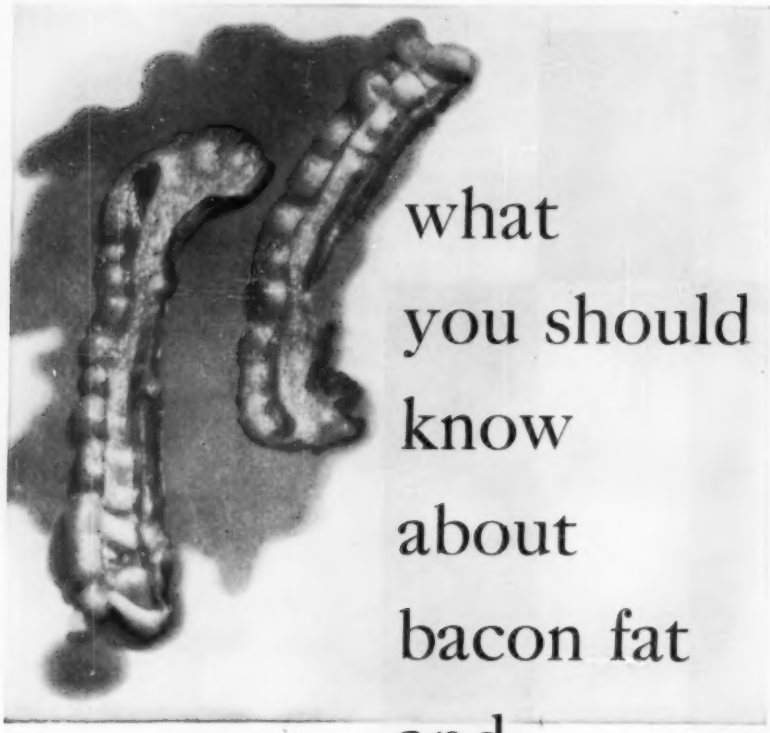

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Materials Progress (Contd.)

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High-strength Bronze.—*Ampco Metal, Inc.,* Milwaukee, Wis., is marketing a new high-strength bronze which was originally developed in England for marine propellers. Called Superston 40, it is a combination of an aluminum bronze and an iron-manganese superbronze. Its approximate composition is 75 per cent copper, 12 manganese, 8 aluminum, 3 iron, and 2 nickel.

The alloy not only has very good casting qualities, but it also can be forged or rolled easily. It is being recommended for gears, slides, valve seats, wire, and heavy-duty mechanical parts. Sand castings have a tensile strength of 98,000 pounds per square inch, with elongation of 26 per cent, and a hardness of 185 Brinell. The wrought metal has a tensile strength up to 135,000 pounds per square inch, with elongation from 15 to 35 per cent depending on the hardness. The hardness may be from 180 to 230 Brinell.

Aluminum Alloy.—A new corrosion-resistant aluminum alloy offered in the form of plate, sheet, and extrusions by *Kaiser Aluminum & Chemical Sales, Inc.,* Oakland, Calif., as Alloy 5086, contains 4 per cent magnesium, 0.45 manganese, 0.10 chromium, and the balance aluminum. As it is not heat-treatable and is not affected by welding heats, welds in the plate can be made nearly equal in strength to that of the base metal. The tensile strength is 38,000 to 47,000 pounds per square inch.

New Ceramic Coating.—A new heat-resistant ceramic coating that does not require high-temperature curing like porcelain and is more resistant to mechanical shock than porcelain has been developed and commercialized by the *Kraus Research Laboratories,* Cockeysville, Md. The material, called Porcelox, is produced from a black halloysite, an aluminum silicate mineral, processed into a colloidal slurry form. It is applied in water solution to clean metal surfaces, and baked at a temperature of 350 to 450 degrees Fahrenheit.

The curing is a simple process of driving off the moisture and the water of crystallization. The resultant coating has a smooth matte finish that will withstand temperatures above 1,100 degrees Fahrenheit and is resistant to sea water and to many chemicals.

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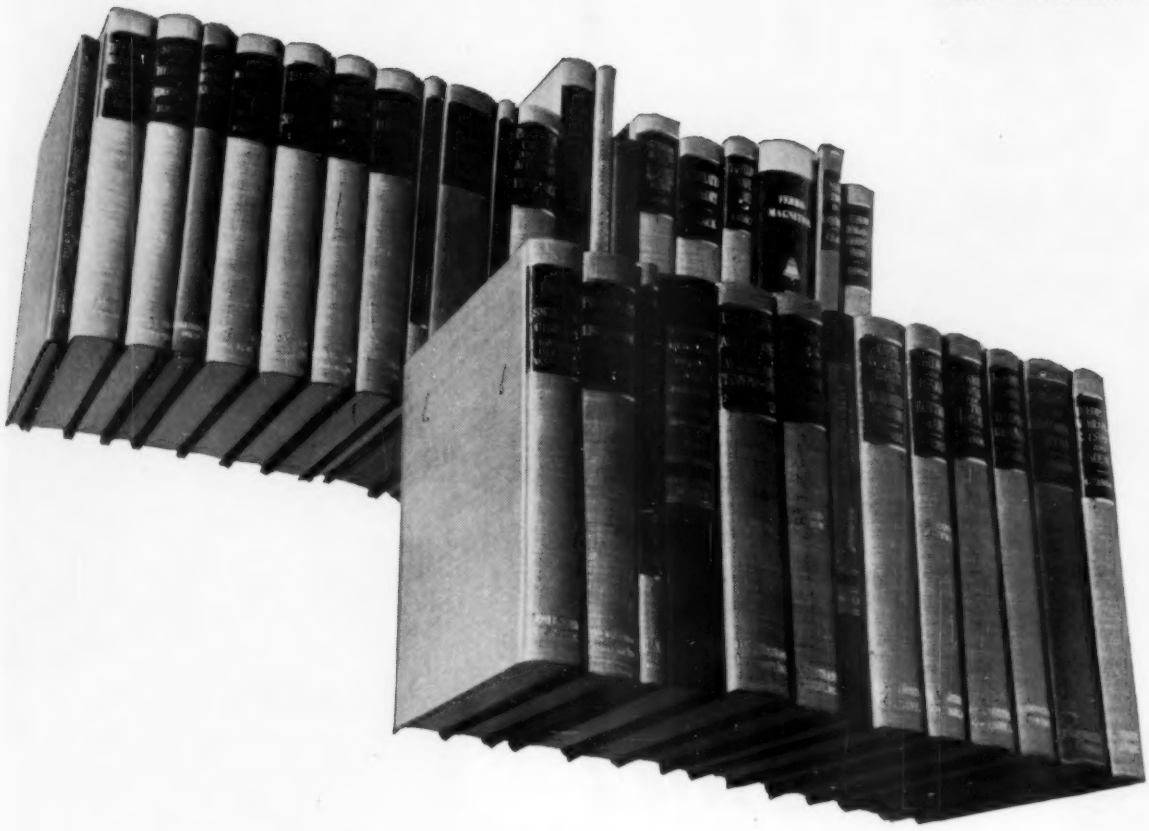

How the scientific world shares in fruits of the telephone art

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ROCKETS AND GUIDED MISSILES

Alfred J. Zaehringer

Astronautics.—With the first *Vanguard* satellite attempt yet a few months off, the effect of the spaceward trend is beginning to shape the minds of our military planning. The Air Force Office of Scientific Research and Convair, prime contractor for the *Atlas* ICBM, held an astronautics symposium in San Diego in February. The meetings were a focal point for an industrial and military appraisal of today's rocket and missile developments. The over-all view was that we should look spaceward for our future defense.

Head of Air Force's ballistic missile program, Maj. Gen. Bernard A. Schriever, said that future wars may be fought in space rather than on the earth or its oceans. He urged U. S. space supremacy and added that intercontinental ballistic missiles should be modified to send vehicles to the moon.

However, Dr. Hermann J. Schaefer of the Naval School of Aviation Medicine stated that much will have to be learned about cosmic radiation, for instance, before we can safely conduct manned space expeditions. One thousand hours of exposure at an altitude of 120,000 feet, for example, would double offspring mutations compared with conditions at the earth's surface.

Another hazard—meteors—was outlined by Dr. Fred L. Whipple, director of the Smithsonian Astrophysical Laboratory Recent data reveal that a meteor hit about every 4 days might be expected by the satellite at 200 miles' altitude. Richard Roche stated that Litton Industries of Beverly Hills, Calif., is building a "space chamber" for the Air Force. This chamber will simulate conditions at an altitude of 200 miles.

Meanwhile, a big propulsion breakthrough is needed for true space travel, stated Jack Irving of the Ramo-Wooldridge Corporation. The physicist, speaking at a recent American Rocket Society meeting at the University of Michigan, said that space flight is impractical with present chemical fuels. He cited the 20,000 pounds of rocket needed to place a 20-pound satellite in orbit around the earth. At the present state of the art we could transport a 650-pound payload to the moon, one way, at the expense of a rocket tipping the scales at about 950,000 pounds (about 8 to 9 times the weight of the anticipated ICBM). Nuclear energy or the energy of light, therefore, must be harnessed to improve the payloads of space vehicles.

At the San Diego meeting, Dr. Ernest Stuhlinger of Redstone Arsenal again proposed his photon rocket, powered by light beams, which could travel at speeds up to 86,400 miles an hour. It was recently announced that the Glenn L. Martin Company has received a contract to study ways and means of building photon rockets for space travel. At the present state of engineering, it takes several tons of rocket to produce one pound of thrust in the form of an ion beam.

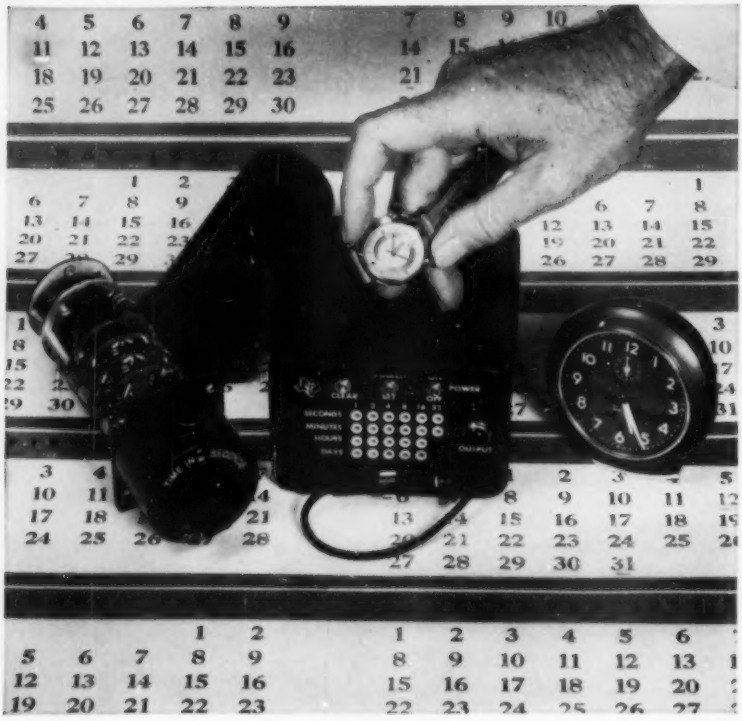
Missiles.—Recently unveiled for the first time was the Bell *Rascal* missile, the GAM-63. The air-to-ground missile is designed to be carried to the vicinity of its target by a manned bomber, dropped, and guided to impact. The range, said to be about 100 miles, would keep the bomber out of the dangerous target area. The missile, of canard configuration, is powered by a 3-cylinder rocket engine burning gasoline and acid and has a top speed of about Mach 1.5.

The Army also gave a new view of its missile, *Lacrosse*. The weapon is described as a guided field artillery missile and is launched from a truck against ground targets. It is being produced by Martin for the Army but it was revealed that the Marine Corps will soon have *Lacrosse* batteries. Power for the new weapon comes from a solid-propellant rocket, and guidance is of the all-weather type.

New mobility for the *Matador* TM-61B missile comes with the Translauncher and Teracruzer using the new "pillow" or bag-type tires. The semitrailer by Goodyear and the tractor by Four Wheel Drive Auto Company enable the *Matador* to be transported over rough terrain. Meanwhile, a new model of the Air Force missile is the TM-61C with improved guidance.

A new model of the *Falcon* is the GAR-1D. The new model is slightly larger than the old 6-foot-long model. Major changes are said to be in controls. The Defense Department recently announced that Air Force interceptors will be equipped with nuclear-warhead air-to-air missiles and that the Army *Nike* may also soon be atomic-equipped.

A preview of the intercontinental *Navaho* missile was given by the North American *X-10* test vehicle. The *X-10* is unmanned and is powered by two jets located at the wing roots. Dihedral delta wings also are featured. The SM-64 *Navaho*



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is currently undergoing tests at the Missile Test Center, Florida. Guidance for *Navaho* is said to be celestial and inertial.

The *X-7* test vehicle by Lockheed also is being tested as a flying laboratory for the ramjets of the *Bomarc* IM-99 long-range ground-to-air interceptor.

The other Lockheed test vehicle, the *X-17*, is a 3-stage solid-propellant rocket. The aërodynamic vehicle is being used to study the reëntry of the IRBM and the ICBM.

Soon to become operational with the Strategic Air Command is the SM-62 *Snark* intercontinental pilotless cruise missile. The Northrop-built *Snark* is launched from an air-transportable pilotless zero-length launcher by means of two solid-propellant booster rockets. A turbojet engine gives the missile a high altitude cruise of about Mach 0.9. The *Snark* is about 69 feet long, has a span of 42 feet and can carry atomic warheads.

Hawk is a new bomber-defense rocket being developed by Cornell Aëronautical Laboratory. Originally the *Hawk* was designed an an antiaircraft missile by Raytheon for Army Ordnance. It is about ten feet long and has a diameter of about nine inches.

The submarine U.S.S. TUNNY has been equipped to carry the *Regulus I* underwater. The missile, with its wings folded, is stored in a sealed deck hangar. On surfacing, the hangar hatch opens, and the missile is slipped out. The wings are unfolded, and the missile is positioned on a deck launcher. The launcher is raised, and the *Regulus* is assisted speedily into the air by means of two solid-propellant booster rockets.

Another submarine weapon is reported to be under development by Aerojet-General for the Navy. A solid-propellant-powered rocket, the *Polaris*, is to be designed to be fired from a submerged submarine against targets over 650 miles away. During World War II the Germans developed small rockets which could be fired underwater, and plans were on the boards for towing V-2's in sealed containers for underwater firing.

Propulsion.—First run of a nuclear-powered jet engine is said to have taken place at the Atomic Energy Commission's National Reactor Testing Station at Idaho Falls, Idaho. In place of gasoline or jet fuel, an atomic reactor is used to supply heat to operate the compressor of a turbojet engine. Presumably the atomic jet engine operates on a closed cycle, obviating the need for expendable fuel. A stream of compressed air is ejected from a nozzle to supply propelling thrust. Another variation of a nuclear-propelled aircraft uses much the same technique to drive a propeller.

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RECENT PATENTS

This department on recent military-industrial patents is being published in ORDNANCE *to keep our readers informed of the latest developments in these fields. The data are compiled by Melvin Nord, patent attorney, Detroit, Mich. Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each.*

Rifle Grenade.—*U. S. Patent No. 2,772,635. Issued December 4, 1956, to Edgar William Brandt. Assigned to Société Anonyme Belge de Mécanique et d'Armament:* This invention relates to a rifle grenade of the hollow-charge type, provided with a base fuze. The advantages of a base fuze as compared with a head fuze are retained; *i.e.*, sensitivity, safety, and regularity of operation. Further, the base fuze provided has great sensitivity and is proof against shocks in the course of transport and handling and in the event the projectile is dropped on its point or base. Accidental explosion of the detonator cannot affect the explosive charge.

The characteristic feature of the invention is that the fuze is housed in an intermediate chamber between the charge carrier body and the base of the grenade, the safety device retaining the detonator, before arming, in the chamber in an inoperative position and outside the charge.

Low-temperature Starting of Gas Turbine Engines.—*U. S. Patent No. 2,771,741. Issued November 27, 1956, to Daniel P. Barnard, IV. Assigned to the Standard Oil Company:* This patent describes a method of starting an aircraft turbojet engine under arctic temperatures. Satisfactory atomization of the viscous jet fuel is assured by introducing normally gaseous hydrocarbons into the primary fuel line leading to the atomizer nozzles. Since only enough of such material need be introduced to dilute the heavy fuel in the line leading to the nozzles in order to permit the formation of ignitable fuel spray patterns, a much smaller quantity of the lighter hydrocarbons is required than when such a material is burned as a priming fuel apart from the primary fuel.

Special Course Torpedo.—*U. S. Patent No. 2,772,647. Issued December 4, 1956, to David C. White:* This invention relates to a gyroscopically controlled course director for a submarine torpedo. The torpedo may be fired when the only information available is the target course (angle on the bow) and instantaneous bearing rate, thus eliminating the necessity for range observations. The torpedo follows a curved course, maintaining a constant angular velocity relative to the firing point, which is manually set in relation to the observed target bearing rate. A reasonable probability of a hit thus exists when the torpedo is fired from any position.

Rocket Propellants.—*U. S. Patent No. 2,774,214. Issued December 18, 1956, to Frank J. Malina and John W. Parsons. Assigned to Aerojet-General Corporation:* The object of this invention is to provide propellants—fuels and oxidizers—which are spontaneously combustible without danger of explosion, thus eliminating the need of an auxiliary system to ignite the propellants. Red fuming or white fuming nitric acid or liquid nitrogen dioxide is used as the oxidizer. The preferred fuels are aniline, pyrrole, and pyridine.

The fuel and oxidizer are in separate containers. The two containers are kept under pressure by an inert gas. Difficulties are avoided by properly relating the initial rates of injection of fuel and oxidizer to the size of the jet chamber so as to avoid explosion during the initial combustion.

Repeating Rocket Launcher.—*U. S. Patent No. 2,774,282. Issued December 18, 1956, to Andrew Ballash, Stephen A. Stam, and Paul E. Anderson. Assigned to the Secretary of the Army:* This patent describes a repeater or semiautomatic rocket launcher in which the launching tube is formed in sections. When the launching tube is opened, a rocket is fed automatically into the tube from a magazine. The advantages claimed for the construction described in the patent are as follows: relatively simple to load and operate, rugged and reliable in construction and operation, and greatly increased firepower of each launcher.

Bottom Firing Detonator.—*U. S. Patent No. 2,774,304. Issued December 18, 1956, to John L. Worzel. Assigned to the Secretary of the Navy:* In deep-water seismic measurements it is often desirable

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Diagrammatic view of the new Willys Forward Control Jeep FC-150 showing the Spicer 4-Wheel-Drive Assembly, including axles, joints, shafts, transfer case; and front, center and rear PowerTake-Off points.

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Recent Patents (Contd.)

to operate a recording mechanism for a long period of time and to proceed away from the recorder while firing charges at the ocean bottom. In order to do this it is necessary to have a detonator which will initiate an explosion precisely at the time at which the explosive charge hits the bottom.

This invention deals with the problem by providing a detonator which initiates an explosion by reason of contact of the explosive charge with the ocean bottom. A percussive material is contained within a pressure-sensitive collapsible closed container. Combined with this is a triggering arrangement responsive to contact with the ocean bottom.

Waterborne Airplane Terminal.—*U. S. Patent No. 2,774,322. Issued December 18, 1956, to Frederic R. Harris. Assigned to Frederic R. Harris, Inc.:* This patent provides a seaplane terminal having the general construction of a floating drydock which can be partly submerged when necessary and raised again in the same manner as in the lifting and repairing of ships.

Aircraft Take-off Carriage.—*U. S. Patent No. 2,744,557. Issued December 18, 1956, to W. J. Jakimiuk and Georges J. Hereil. Assigned to Société Nationale de Constructions Aéronautiques du Sud-Est:* This patent provides an assembly for conveying over and launching from rough ground an aircraft having a retractable landing gear.

Production of Colored Smokes.—*U. S. Patent No. 2,775,515. Issued December 25, 1956, to Sidney J. Magram. Assigned to the Secretary of the Army:* This invention relates to the production of airborne suspensions of coloring materials in the form of clouds or smokes. The object is to provide a substantial reduction in the amount of coloring material or dye used per unit munition without loss of effective color intensity of the clouds produced. This is accomplished by disseminating throughout the coloring agent particles of a finely divided inert dispersing agent, such as silica gel powder.

Acoustisonde Apparatus.—*U. S. Patent No. 2,750,794. Issued June 19, 1956, to George W. Downs. Assigned to the Secretary of the Navy:* This invention describes apparatus for measuring and recording certain properties of the sea. Signals indicative of pressure, temperature, turbidity, salinity, and radioactivity are detected by a submerged apparatus and transmitted as sound through the water to receiving and recording apparatus at the surface. The submerged apparatus is self-contained and may be lowered on a cable from a ship or cast free to send back complete data.

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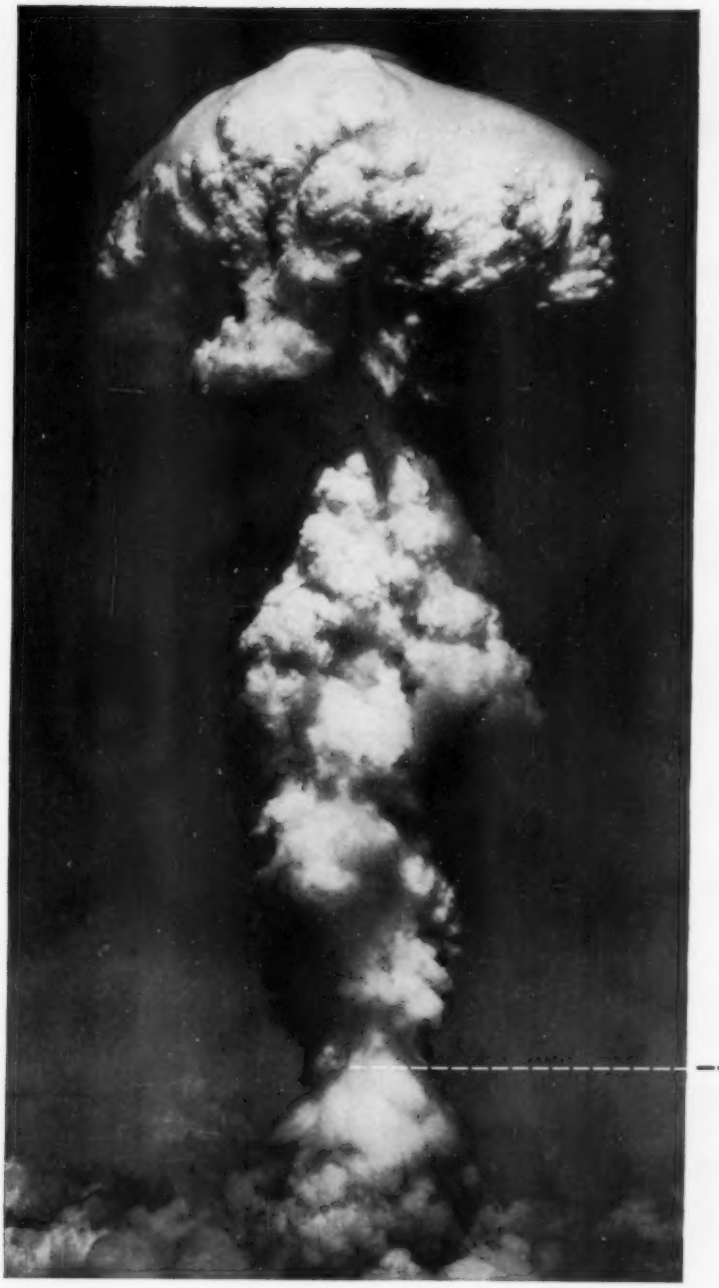

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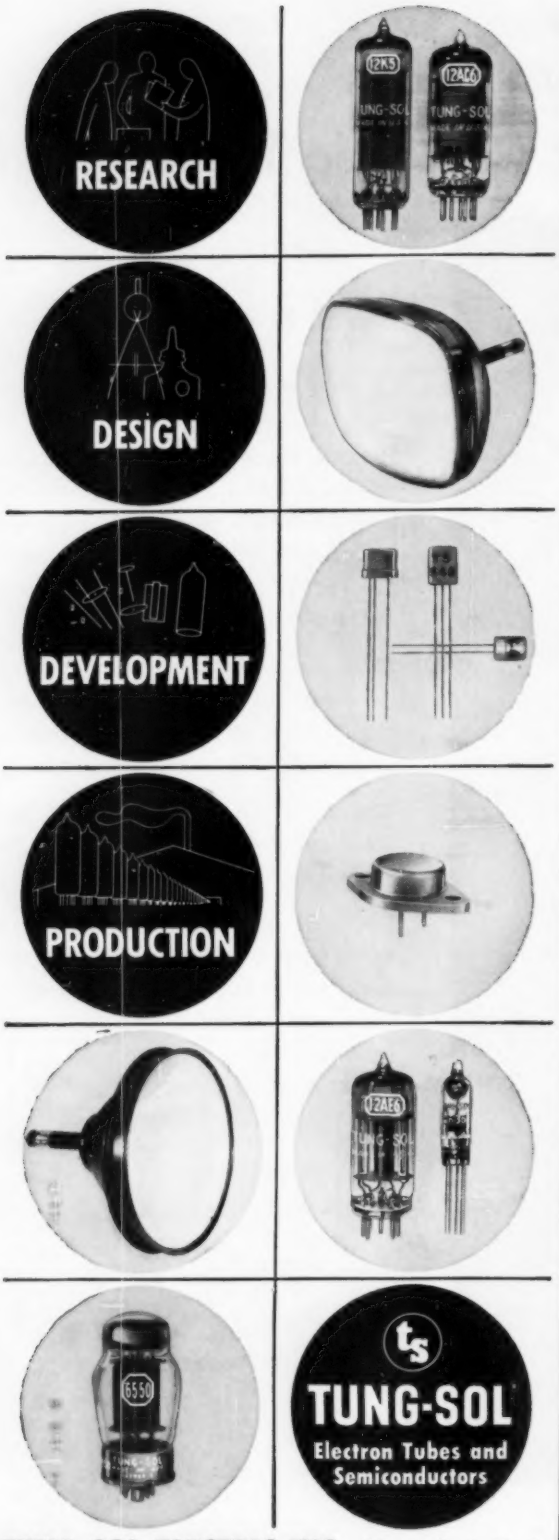

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Book REVIEWS

Reviews in this issue by:

COL. GEORGE S. BRADY, *consulting engineer, author, editor, Washington, D. C.*

COL. LEO A. CODD, *editor of* ORDNANCE, *Washington, D. C.*

COL. JOHN J. DRISCOLL, *author, air armament engineer, Weapons Systems Evaluation Group, Office, Secretary of Defense, Washington, D. C.*

DR. J. B. EDSON, *consultant on electronics, Research and Development Division, Office, Chief of Army Ordnance, Washington, D. C.*

F. W. FOSTER GLEASON, *military historian, ordnance analyst, editor, Washington, D. C.*

C. MEADE PATTERSON, *small arms expert, Washington, D. C.*

ORVILLE C. SHIREY, *major, Infantry, United States Army Reserve, Washington, D. C.*

CAPT. J. M. P. WRIGHT, *U.S.N. (Ret.), naval ordnance engineer, logistician, editor, Washington, D. C.*

Atomic Quest. By Dr. Arthur Holly Compton. New York: Oxford University Press. 370 pp. $5.

SINCE atomic bombs crashed into Japan in August 1945, no personal account of the struggle to build the bomb appeared until this excellent narrative. Dr. Compton has an unusually broad range of interests and tells the story of his part in the bomb development in an easy style and with great modesty.

His on-the-scene account brings in the great scientific personages who were involved in the supersecret Manhattan District Project, such as Vannevar Bush, Enrico Fermi, J. R. Oppenheimer, J. B. Conant, E. O. Lawrence, and the project director, Lieut. Gen. Leslie R. Groves.

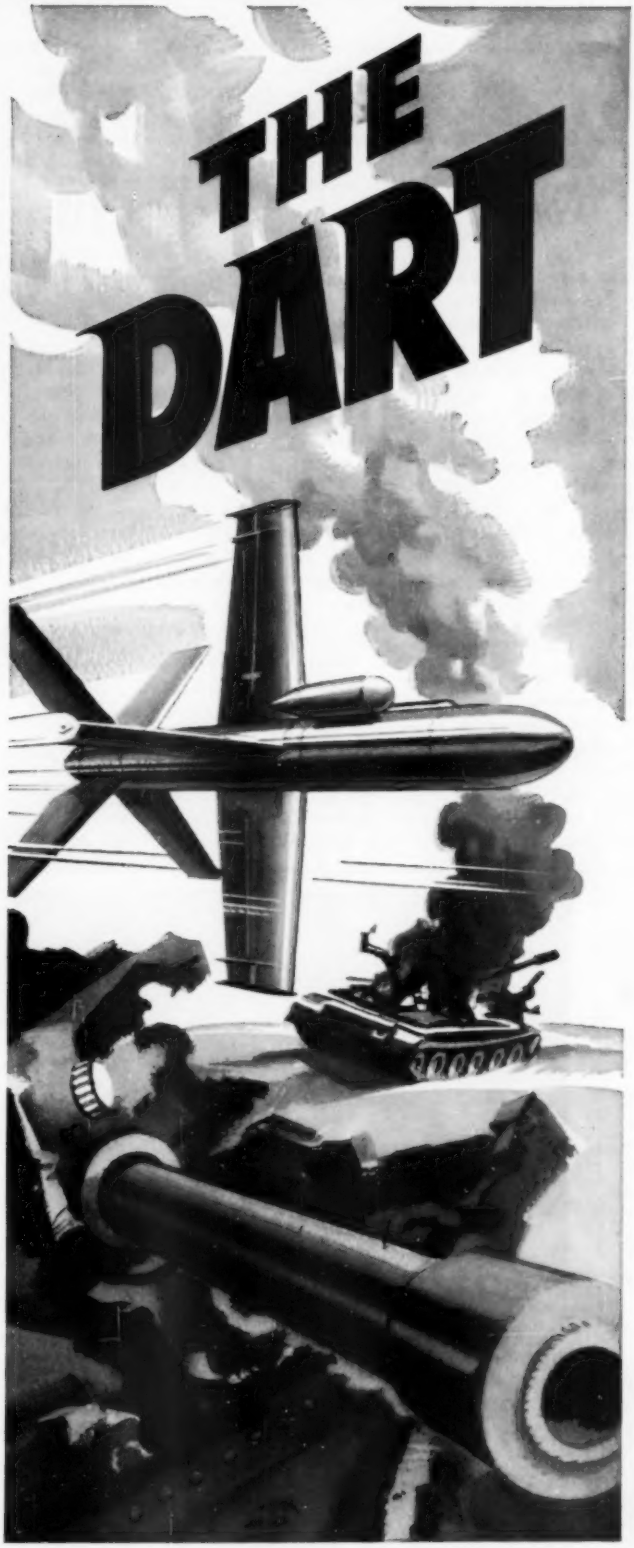
Some fascinating aspects of the project were the uncanny accuracy of predictions by the top scientists as to completion dates of contributing efforts, the amazing amount of information on plutonium gleaned from a microscopic particle, and the prodigious feats of industry in erecting and operating plants to make a strange and dangerous product.

In these times of troubled peace it seems extraordinary that the multifold problems involved in utilizing nuclear energy were solved in so short a time. This story of unsurpassed scientific achievement should inspire a large body of young men to pursue a scientific education—provided the older men will "rub the noses" of the youngsters in this book.—J. M. P. WRIGHT

The Secret War, 1939-1945. By Gerald Pawle. New York: William Sloane Associates, Inc. 297 pp. $5.

THIS is the story of the Miscellaneous Weapons Development Department of the British Admiralty. It describes development work with the flame thrower, the spigot mortar and the Hedgehog, the balloon barrage, the "Swiss Roll," the rocket grapnel, and the floating breakwater.

Not all the inventions were successful. The great rocket-driven wheel, the Panjandrum, was erratic and would turn back or fall on its side and shoot its driving rockets in all directions. Some



Rocket-propelled SURFACE MISSILE gives wings to ground combat

The fast and powerful Dart is a rocket-propelled surface-to-surface missile designed for Army Ordnance by the Aerophysics Development Corporation, a subsidiary of Curtiss-Wright.

While its design and performance are classified, the Dart has been described as a simple but effective anti-tank missile—a single hit from which would probably destroy a heavily armored tank. The five-foot long, highly maneuverable missile has a smokeless-propellant rocket motor.

The Dart represents one of the Army's most advanced ground combat weapons. Another development in the Curtiss-Wright propulsion family, it is typical of Curtiss-Wright's leadership in power to preserve peace.

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things were used in ways not intended by the designers, as when a ship captain found that magnesium flares made effective weapons for flooding an opposing ship's decks with hot flame. Some good inventions had to be developed against aggravating opposition.

Technical men had a weary siege in trying to get the Admiralty to adopt the Oerlikon antiaircraft gun, which could spew 450 shells a minute. Debate dragged for 18 months through 300 conferences, and only the insistence of Lord Mountbatten and Winston Churchill won its adoption. The author believes that it is easier to evolve a new weapon than it is to pilot it through a maze of officialdom to get it field-tested and approved. On the other hand, the scientists also had their shortcomings. If left alone, they tended to experiment eternally, always looking for a better design tomorrow, and they needed the urging of some one willing to take a "calculated risk." The book ranks as "must reading" for any one responsible for seeing that advanced equipment is ready for an emergency.—GEORGE S. BRADY.

The Battles that Changed History. By Fletcher Pratt. New York: Hanover House. 348 pp. $4.95.

THAT this volume follows the century-old general order of Creasy's "Decisive Battles" by no means types it as a mere variant of its famous prototype. Fletcher Pratt's approach is as fresh as it is sound. His choice of actions, sixteen in number, has been made because of their decisiveness on sometimes-far-distant results and policies rather than the importance of the immediate field.

Thus the series of naval actions of Admiral Suffren in the Cape Verdes and off the coast of India in 1781 are shown to be truly decisive of Britain's foregoing any further attempt to recover her American Colonies. And the earliest signs of the crack-up of the Turkish Janissaries may be interpreted in much the fashion of the current unrest of the Communist sattelites.

Not all readers will agree with all of Pratt's conclusions in this work, but few will doubt the soundness of his thesis. It is a book that invites much thought and further study, while furnishing a deal of fascinating reading.—F. W. FOSTER GLEASON.

The Red Army. Edited by B. H. Liddell Hart. New York: Harcourt, Brace & Company. 480 pp. $6.

HERE is a mammoth summation (480 pages) of a great army compiled by Liddell Hart. Possibly because his "The German Generals Speak" was so well done, this volume suffers by comparison. "The Red Army" has its merits—but they are limited. Only one essay among the forty-four which comprise the work attempts to tell about the present strategy and armament of the Red Army, and it is anonymously written for obvious reasons.

The book is divided into two main sections, the first consisting of eighteen essays on the Red Army from 1918 to 1945. There is some excellent history in this section from which many of the gaps that have existed until now can be filled. Most of the authors are either experienced military men or qualified civilian students.

The second section of the book is made up of twenty-six essays on the Soviet Army, 1946-1955. Again, many of the authors are eminently qualified.

Unquestionably, the best part of the book is the prologue written by Captain Hart himself. As readers of this journal know from his frequent contributions to these pages during the past quarter century, his is an expert pen moved by a superb mind and governed by a broad experience.—LEO A. CODD.

Death of a Navy. By Capt. Andrieu d' Albus, French Naval Reserve. Translated by Anthony Rippon. New York: Devin-Adair. 362 pp. $5.50.

THIS is an account of Japanese naval actions in World War II by a trained naval officer. Captain d' Albus' familiarity with Japanese language and customs is evident in his discussions of the decisions made by

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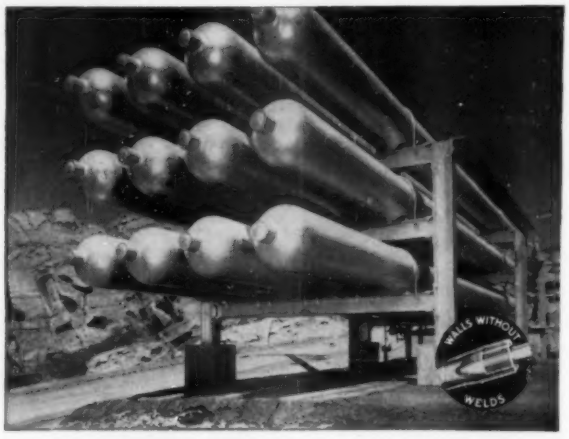

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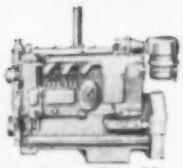

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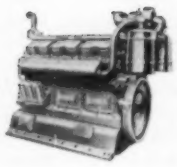

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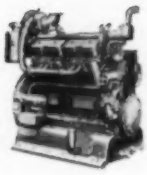

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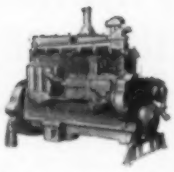
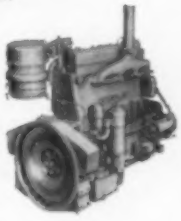
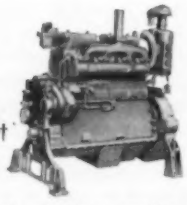


Also available as an electric set. Choice of air, electric or gasoline starting system.

NEW D315 (Series G) Turbocharged **115 HP†**

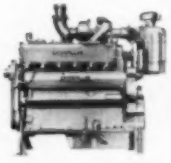


D339 Naturally Aspirated **140 HP†**



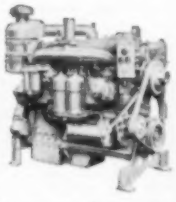
Choice of air, electric or gasoline starting system.

D337 with Turbocharger **310 HP†**

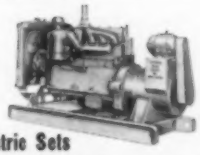


Also available as an electric set or torque converter power unit. Choice of air, electric or gasoline starting system.

D326 Naturally Aspirated **200 HP†**



Also available as an electric set or torque converter power unit. Choice of air, electric or gasoline starting system.



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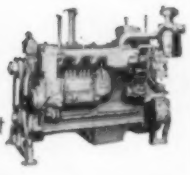
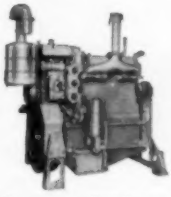
D318 Naturally Aspirated **137 HP†**



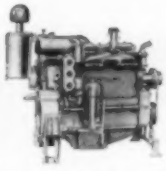
Also available as an electric set or torque converter power unit. Choice of air, electric or gasoline starting system.

D315 Naturally Aspirated **91 HP†**

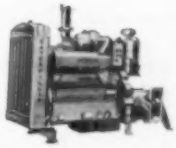


Also available as an electric set or torque converter power unit. Choice of air, electric or gasoline starting system.

D311 Naturally Aspirated **65 HP†**



Also available as an electric set. Choice of air, electric or gasoline starting system.



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†maximum output capacity

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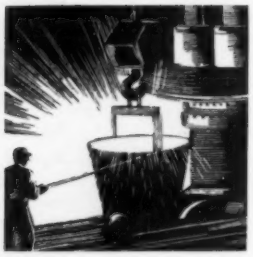

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L-106

Book Reviews (Contd.)

the Japanese admirals and their difficulties in dealing with the Japanese Army.

Most of the book is devoted to the first phases of the war, and the author shows that the Japanese Navy was faced with defeat long before the war's end.—J. M. P. WRIGHT.

The Central Blue. The Autobiography of Sir John Slessor, Marshal of the R.A.F. New York: Frederick A. Praeger. 709 pp. $7.50.

ONE autumn night in 1915, a young Royal Flying Corpsman in a BE-2C climbed to altitude in pursuit of a Zeppelin intruder, but the lumbering German airship dropped her ballast and outclimbed the 90-horsepower airplane. The R.F.C. pilot was 2nd Lieut. John Cotesworth Slessor whose mission was to employ the then-standard procedure of dropping a small can of gasoline (attached to a bunch of large fishhooks) onto the Zeppelin's envelope. This incident initiated the fascinating combat career of one of the world's most distinguished airmen, Sir John Slessor.

With his assignment as Director of Plans of the British Air Ministry in May 1937, he was soon to have worldwide impact upon the future of air warfare. Despite the general lack of experience and the R.A.F.'s prior neglect of bombing techniques, Slessor pioneered in the key fields of target vulnerability and weapons selection and tactics. These studies provided the foundation for the air war over Germany and subsequently proved vital to the education of the U.S.A.A.F.'s fledgling (1942) Eighth Air Force.

Air Marshal Slessor gives an eyewitness account of "the tragic and shameful events" which led the British to the brink of disaster in 1939. He presents a carefully documented review of Munich and the prewar R.A.F. expansion programs, the establishment of the R.A.F. bomber policy, the "Phoney War," the Battle of the Atlantic, the operations in support of Tito, and the tragedy of Warsaw.

Sir John must stand corrected on one important facet of his autobiography. He reproduces in full his 1938 report to the Air Ministry of the discussions he held that September with Col. Charles A. Lindbergh who had recently completed a unique on-the-spot inspection of the Luftwaffe organization and the German aircraft industry. In line with many anti-Lindbergh rantings of that period, Slessor's 1938 evaluation of Lindbergh's reported observations was that they were "a striking example of the effects of German propaganda."

Sir John seriously doubted the Lindbergh estimate of the productive capacity of the German aircraft industry—500 to 800 a month. Slessor also implies that the twenty modern bombers seen by Lindbergh in one factory were prearranged to impress him.

Actually, firsthand postwar studies by this reviewer have revealed that Lindbergh's production capacity estimate was very reliable. With one type fighter alone (ME-109) the output had reached 200 a month, and the inclusion of other types (fighter, bomber, and reconnaissance aircraft) made Lindbergh's figures amazingly accurate. This one erroneous evaluation does not, however, materially detract from an otherwise apparently unbiased appraisal of the military and political implications of the air war in Europe (1939-1945).

Slessor's "birdman's-eye view" is recommended to all concerned with the history of the capabilities and limitations of air power.—JOHN J. DRISCOLL.

This Hallowed Ground. By Bruce Catton. New York: Doubleday & Company. 437 pp. $5.95.

"THIS Hallowed Ground" is subtitled "The story of the Union side of the Civil War." This is accurate as far as it goes, but it does not go nearly far enough.

It is very true that Mr. Catton has written an admirably clear and objective military history of the Civil War. Here, in a comparatively short book, are the full sweep of the Northern strategy as old Winfield Scott first saw it and as it finally developed, the

wholesale bloodletting that marked the great battles, and penetrating analyses of the chief commanders.

Mr. Catton's combat narrative is remarkable for its descriptive power and for its clarity, but it is not detailed military history. In this book he is after bigger game. He has set out to put into words the meaning of a war that has become a part of the American heritage as no other war ever has. Certainly the meaning of the Civil War was imperfectly understood in the days of battle. Perhaps we can grasp dimly now that what took place was not simply a war but a cataclysmic upheaval of society.

Mr. Catton views the Civil War as atonement for a national wrong—an atonement which we are still making.—ORVILLE C. SHIREY.

Gran'pappy's Pistol, or to Hell with Gun Collecting. By Duncan McConnell. New York: Coward-McCann, Inc. 152 pp. $3.50.

THIS humorous book has been written by a gun collector who has been able to disassociate himself objectively from gun collecting long enough to look over the field and point out some of its striking problems and peculiarities. His personal observations and experiences arising from gun collecting activities in Colorado, Pennsylvania, Ohio, Illinois, and Virginia provide entertaining reading.

Although it is a satire on gun collecting, the author gives many helpful hints for the novice collector on the best ways not to collect firearms, drawing from his own experience. Helpful suggestions are given on how to repair and shoot muzzle-loading firearms. A glossary of collecting and firearms terms is included as much for humor as for enlightenment. This book full of dry wit makes an excellent gift for gun-collecting friends.—C. MEADE PATTERSON.

The New World of the Atom. By James Stokley. New York: Ives, Washburn, Inc. 288 pp. $5.50.

AUTHOR Stokley has "done his homework" with thoroughness and care. He has boiled down and rearranged the essence of many bulky official documents into a text simple in language and historical in flavor. The result is a ready reference volume that should be useful to serious study groups and public libraries. It will also be of interest to the reader desiring an over-all picture of atomic problems.

It reviews elementary nuclear physics and the world's energy requirements. It outlines the uses of atomics in industry, agriculture, medicine, and biology. There are chapters on "Pandora's Box," "Power for Peace," and "International Control," mostly devoted to the historical facts. There is an excellent selection of photographs and diagrams.

Author Stokley holds America's only professorship of science writing, at Michigan State University. In 1955 he prepared for the United Nations a background paper for the Geneva Conference on Atomic Energy. That conference is among the many recent atomic events authoritatively reported in his book.—J. B. EDSON.

Across the High Frontier. The story of test pilot Maj. Charles E. Yeager, U.S.A.F. By William R. Lundgren. New York: William Morrow & Company. 288 pp. $3.75

IN his narrative style the author here relates the life story of Maj. Charles E. Yeager who, almost ten years ago, was the first to penetrate the "brick wall" of the sonic barrier, proving that this "barrier" existed only in theory, and he describes his subsequent pioneering in many other flight tests which have similarly aided the great aëronautical progress in the United States.

The reader is taken through the inner workings of the U.S.A.F. Flight Test Center and given an introduction to

(*Continued on p. 1054*)

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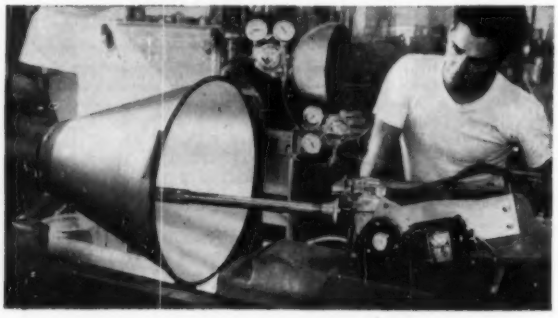

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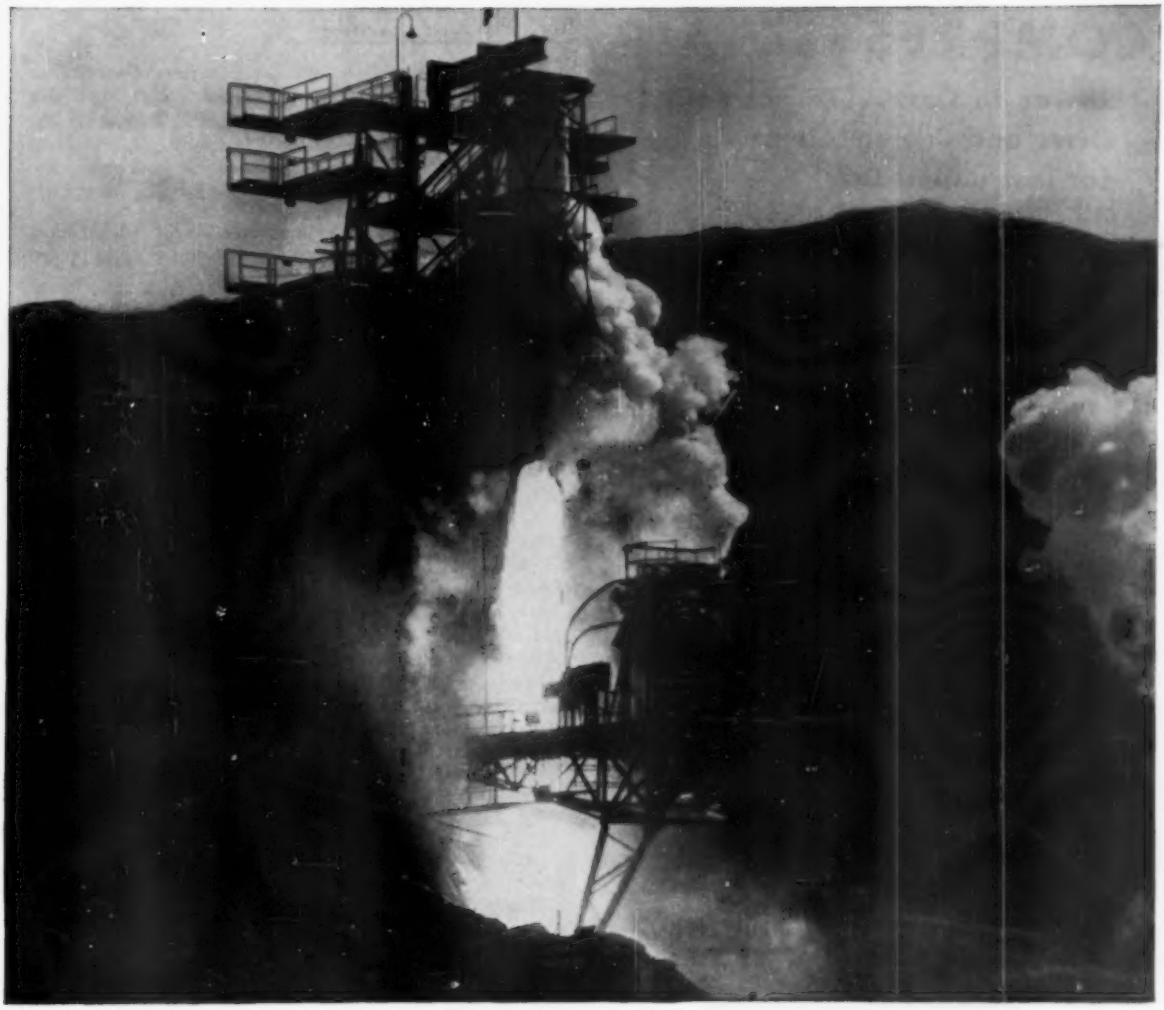

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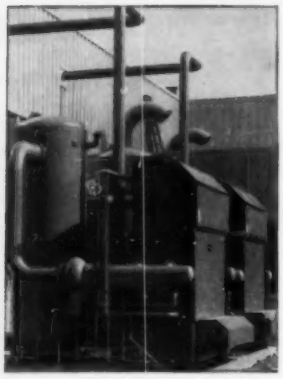

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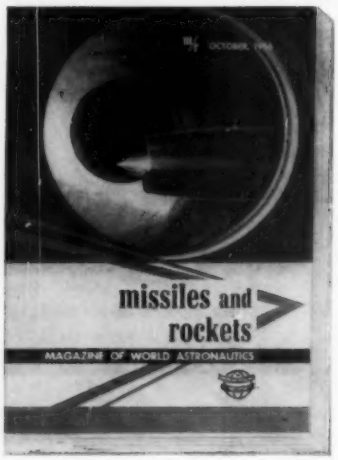

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Magazine of World Astronautics

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Book Reviews (Contd.)

leading U. S. personalities. William Lundgren offers a close approach to actual participation in a high-altitude supersonic flight program, interwoven with the actual dialogue of the participants both on the ground and in the air. This is an excellent documentary of what is probably the most progressive period in the evolution of manned flight.—JOHN J. DRISCOLL.

Twenty Million Tons under the Sea. By Rear Adm. Daniel V. Gallery. Chicago: Henry Regnery Company. 344 pp. $5.

THIS book can be considered from two angles, either as an interesting and exciting sea story for the average reader or as an informal account of important phases of the Battle of the Atlantic from which some things regarding tactics and rough-and-ready fighting may be learned that are not found in ordinary military texts.

It is really the story of the capture of the German submarine U-505, but it brings in enough of the stories of other submarines, the Allied task forces, and the U-boat base at Lorient to orient the reader to understand the whole battle operation. The capture of the U-505 was not a chance affair but was planned in advance with a careful firing scheme to avoid sinking her and with boarding parties ready to take over before the Germans had a chance to destroy the vessel.

After the British and American sub-chasing activities had been coördinated and improved, the Germans were losing one submarine for every Allied ship sunk, and service in the submarines meant almost certain doom.

The book is worth reading either for pleasure or as a study of war operations. It has too many salty wardroom expressions for recommendation to juvenile libraries but nothing that will shock the ordinary sailor.—GEORGE S. BRADY.

BOOKS RECEIVED

American Defense and National Security. By Timothy W. Stanley. Washington: Public Affairs Press. 202 pp. $3.25.

Antennas. By Alexander Schure. Electronic Technology Series, Vol. II. New York: John F. Rider Publisher, Inc. 88 pp. $1.50 paperbound.

Communism on the Decline. By George C. Guins. New York: Philosophical Library. 287 pp. $7.50.

Economic Factors in the Growth of Russia, The. By Nicholas L. Fr.-Chirovsky. New York: Philosophical Library. 178 pp. $3.75.

Elements of Gasdynamics. By H. W. Liepmann and A. Roshko. New York: John Wiley & Sons, Inc. 439 pp. $11.

Energy. By Sir Oliver Lodge. New York: John F. Rider Publisher, Inc. 64 pp. $1.25 paperbound.

Gun Trader's Guide. By Paul Wahl. Revised Second Edition. New York: Greenberg Publisher. 255 pp. $5.

Handbook of Rockets and Guided Missiles. By Norman J. Bowlan. Chicago: Perastadion Press. 328 pp. $6.50.

Noncom's Guide, The. Twelfth Edition, January 1957. Harrisburg: The Military Service Publishing Company. 489 pp. $3.

Officer's Guide, The. Twenty-third Edition. Harrisburg: The Military Service Publishing Company. 505 pp. $5.

Principles of Personal Finance for Service Personnel. By associates in the social sciences, U.S.M.A. Harrisburg: The Military Service Publishing Company. 176 pp. $2.

Proceedings of the Second RETMA Conference on Reliable Electrical Connections. New York: Engineering Publishers. 103 pp. $5.

Radiation Safety and Major Activities in the Atomic Energy Programs, July-December 1956. Washington: U. S. Government Printing Office. 396 pp. NP

Wave Propagation. By Alexander Schure. Electronic Technology Series, Vol. II. New York: John F. Rider Publisher, Inc. 64 pp. $1.25 paperbound.

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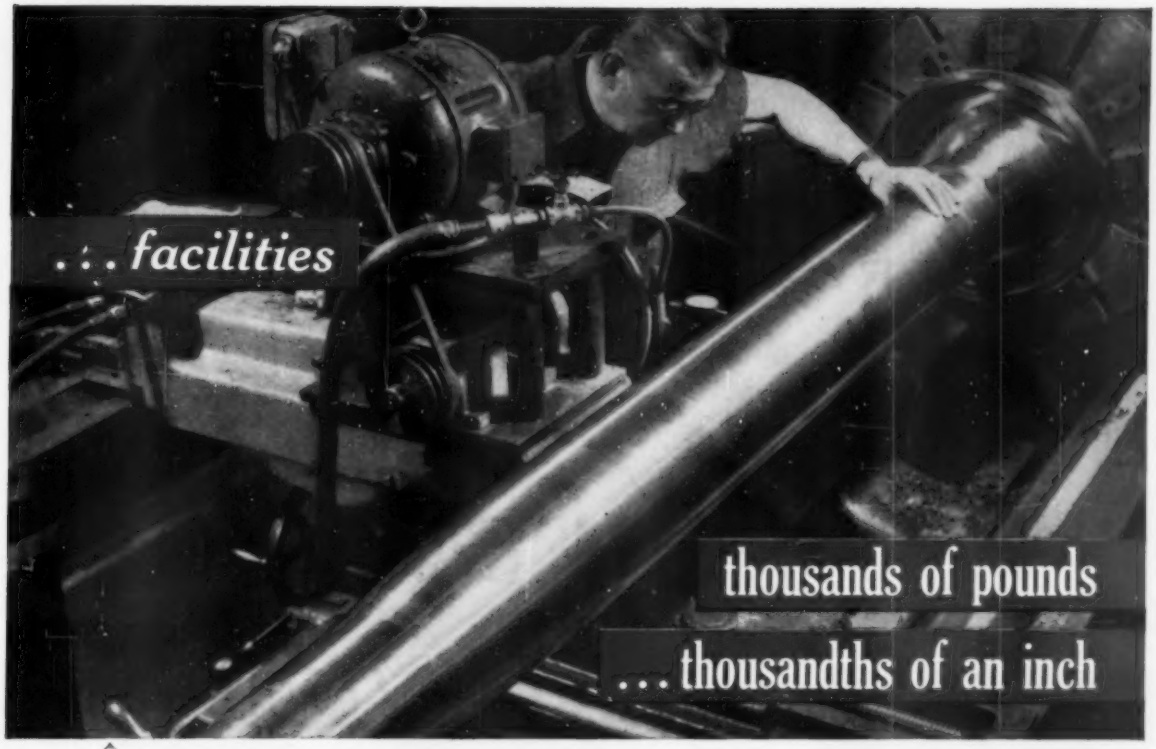

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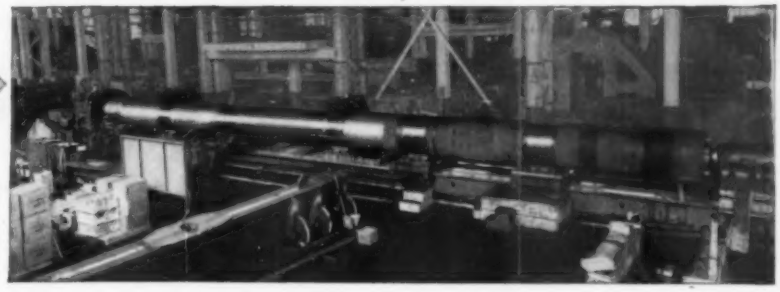
Add these facilities to your own: 11 plants • 2,000,000 sq. ft. • An estimated $44,000,000 inventory of modern tools • Two Meehanite foundries, one iron and one steel foundry • Two fully equipped welding departments.

140-TON FORGINGS. The 70-foot tie rods for the great hydraulic presses built under the Air Force Heavy Press Program filled little more than half the 120-foot bed of this huge engine lathe. It is one of the more-than-100 lathes in Bliss' 675,000 sq. ft. Canton, Ohio, plant.



SPERRY ANNOUNCES

TWO NEW WEAPON SYSTEMS DIVISIONS

CARL G. HOLSCHUH, *President of Sperry Gyroscope Company.*

"In the years ahead, the nation's requirements for new and more efficient weapon systems, delivered at maximum speed and minimum cost, will impose greater demands on industry. For its part, Sperry is moving to meet these demands with the formation of our new Air and Surface Armament Divisions.

"Objective of this product-team realignment within the Sperry organization is to assure more advanced design, shorter lead times and lower costs in the development of weapon systems in these two categories. Each division, with its own engineering, manufacturing and contract organization, includes specialists in radar, fire control, gyroscopics, navigation, inertial guidance and all the allied sciences essential in the engineering of complex weapon systems."

C G Holschuh

SAMUEL AGABIAN has been appointed Manager of the Air Armament Division. Formerly works manager, Mr. Agabian is an Annapolis graduate and former Marine Corps officer. His work at Sperry has included responsibility for computing gunsights, bombsights, antiaircraft devices, radar and infrared developments.

AIR ARMAMENT

Air-to-air missiles and systems
Air-to-surface missiles
Airborne radars
Airborne beacons
Airborne electronic countermeasures
Bombing-navigation systems
Aircraft fire control radars
Airborne inertial systems

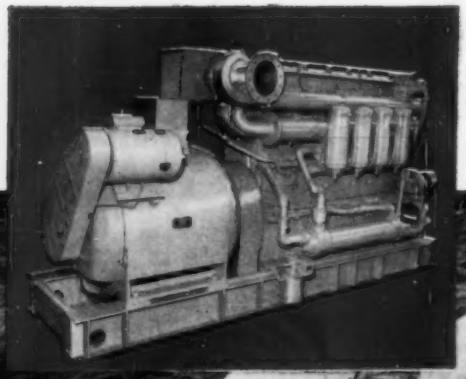
MYRON D. LOCKWOOD, manager of the Surface Armament Division, was formerly a systems engineering director. A World War II Lt. Col. of Artillery, and military-technical advisor at M.I.T., Mr. Lockwood has been associated with Sperry projects in underwater torpedo fire controls, guidance computers for missiles, antiaircraft control systems and inertial navigation equipment.

SURFACE ARMAMENT

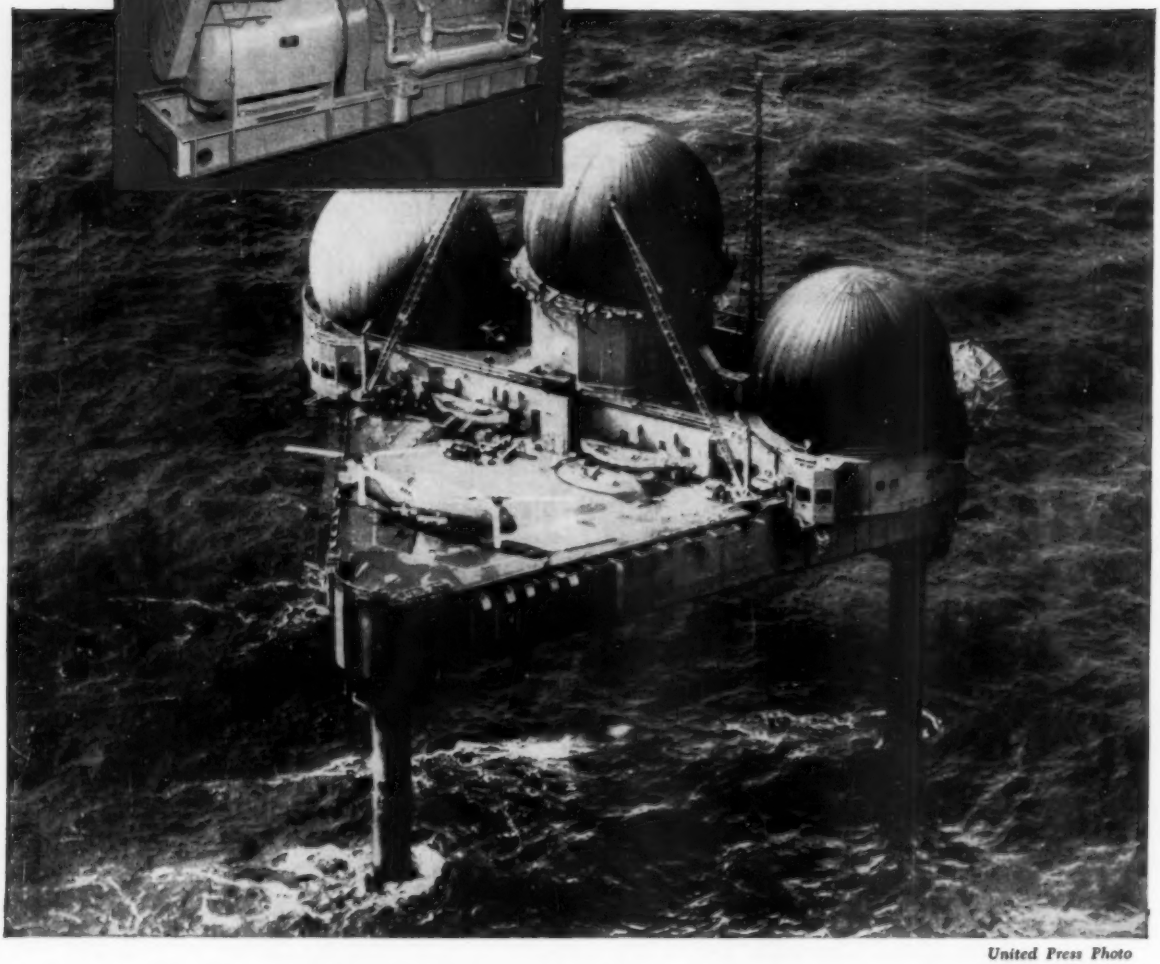
Surface-to-surface missiles
Surface-to-air missiles
Ground and shipboard search radars
Ground and ship tracking radars
Battlefield surveillance equipment
Mortar and artillery locators
Land, ship and submarine fire control systems
Computers
Land and ship-based transmitters
Weapon direction systems
Ground and ship-based electronic countermeasures

SPERRY GYROSCOPE COMPANY
Great Neck, New York

DIVISION OF SPERRY RAND CORPORATION



Powered by White's Superior Diesels...



United Press Photo

TEXAS TOWERS' WARNING WILL ALERT OUR NATION

This U. S. Air Force early warning radar station off the coast of Cape Cod is called the Texas Tower. Aboard the Tower, radar eyes search the skies. In the event of approaching enemy bombers, a push of one red button will warn our coastal areas and start our air defense into action!

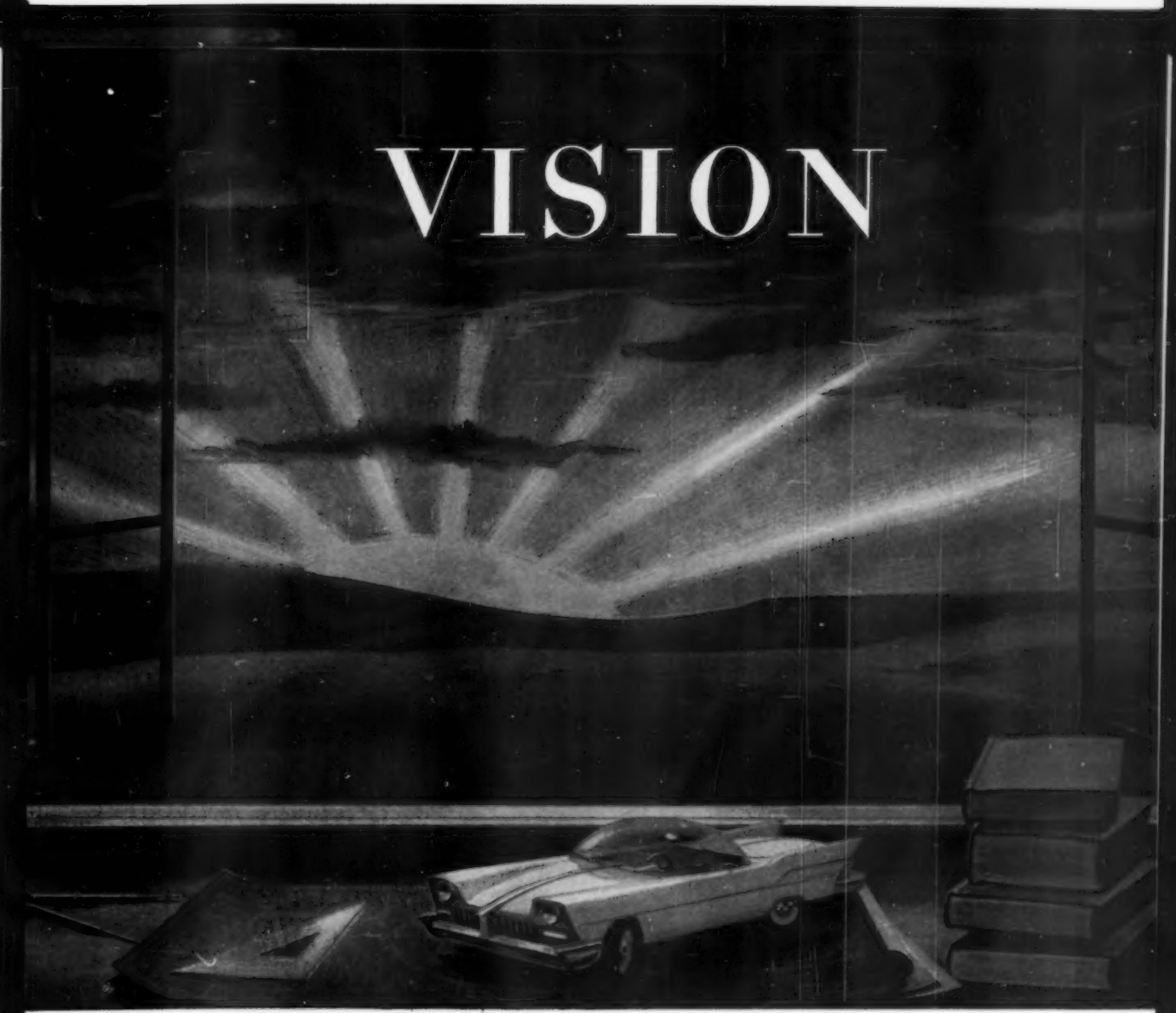
Two more Towers are now being built for the U. S. Air Force by the U. S. Navy, to be a vital part of our nation's far-reaching radar air defense system. They require high-quality, heavy-duty equipment giving dependable performance with minimum maintenance over long periods of continuous service. White's Superior Diesel engines meet these requirements . . . they have been selected to generate the power for the vital radar operations, and also for the radio, communication, heating, lighting and ventilating equipment aboard the additional Towers.

If you require rugged, heavy-duty, high-quality Diesel engines for the most dependable and economical operation, choose White's Superior Diesels. There's a size and type for virtually every requirement from 215 to 2150 horsepower, or 150 to 1500 KW. Get complete information now.

Superior ENGINES — ATLAS — White DIESEL

WHITE DIESEL ENGINE DIVISION

THE WHITE MOTOR COMPANY *Plant and General Offices: Springfield, Ohio*



LOOKING TO THE FUTURE—PRODUCING FOR TODAY!

Progress has been the keynote of the automotive industry. Today's achievements are but challenges for the accomplishments of tomorrow.

Over the years Bendix Products Division has contributed significantly to automotive progress. From four wheel brakes to power braking and power steering, Bendix has pioneered and developed many of the industry's most notable advancements.

And today Bendix Products Division is planning new and better products for the cars and trucks of tomorrow.

That's why the industry looks to Bendix* as a source of new ideas, as well as a volume manufacturer of automotive components.

*REG. U.S. PAT. OFF.

TYPICAL EXAMPLES

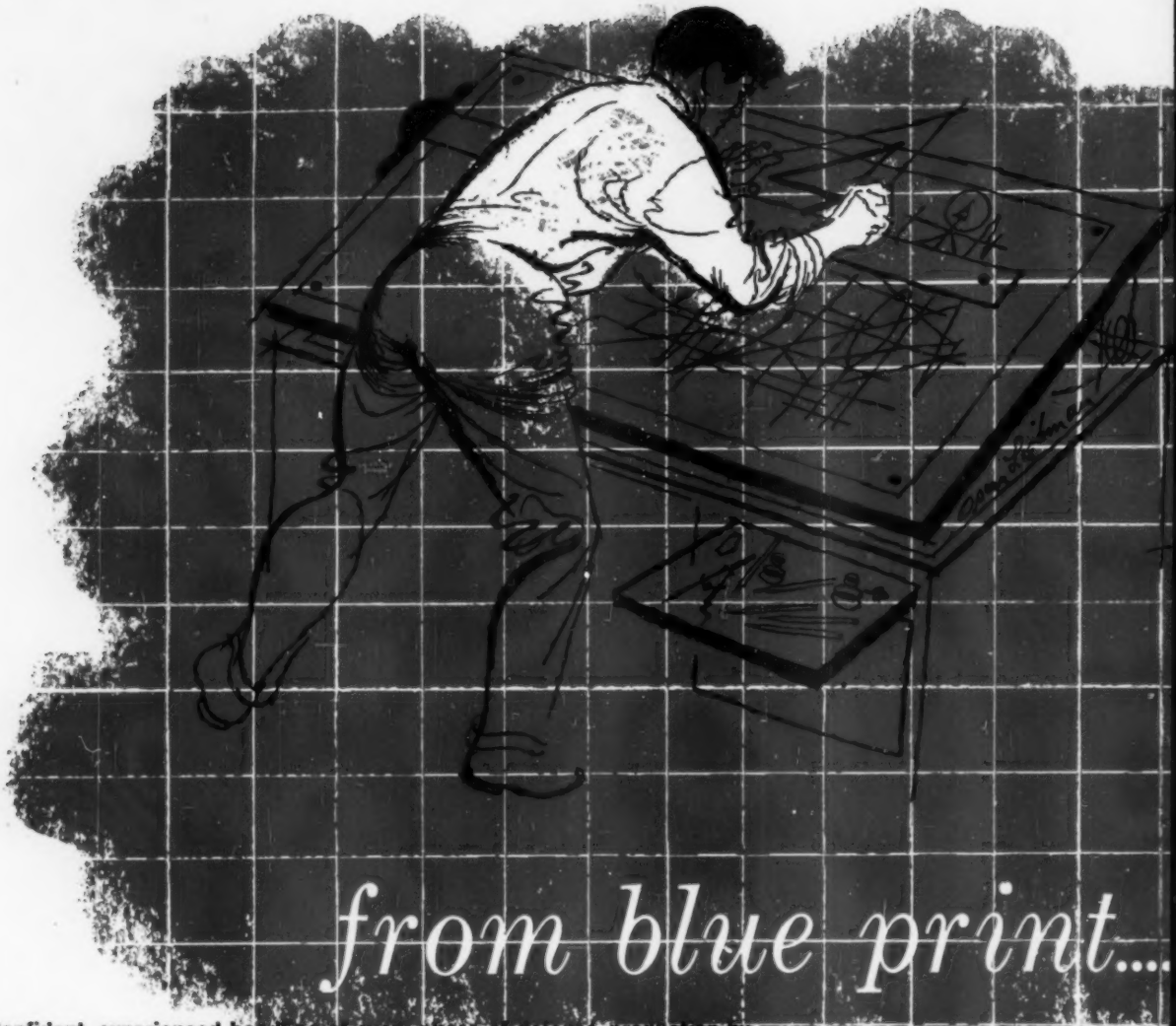
Bendix Power Brakes

Bendix Power Steering

BRAKES • POWER STEERING • POWER BRAKING
CONSTANT VELOCITY UNIVERSAL JOINTS • HYDRAULIC REMOTE CONTROLS

Bendix PRODUCTS DIVISION South Bend, IND.

Bendix AVIATION CORPORATION



from blue print....

Confident, experienced handling of every phase of defense production by specialized engineering teams . . . Four Hoffman facilities equipped and manned for research, development and manufacturing, from individual contracts through multi-stage programs.

This new **AIR PARTICLE MONITOR** makes possible continuous, unattended recording of airborne alpha, beta or gamma radiation, with sensitivity never before available in instruments of this type. Another precision product of

ANTON ELECTRONIC LABORATORIES, INC.

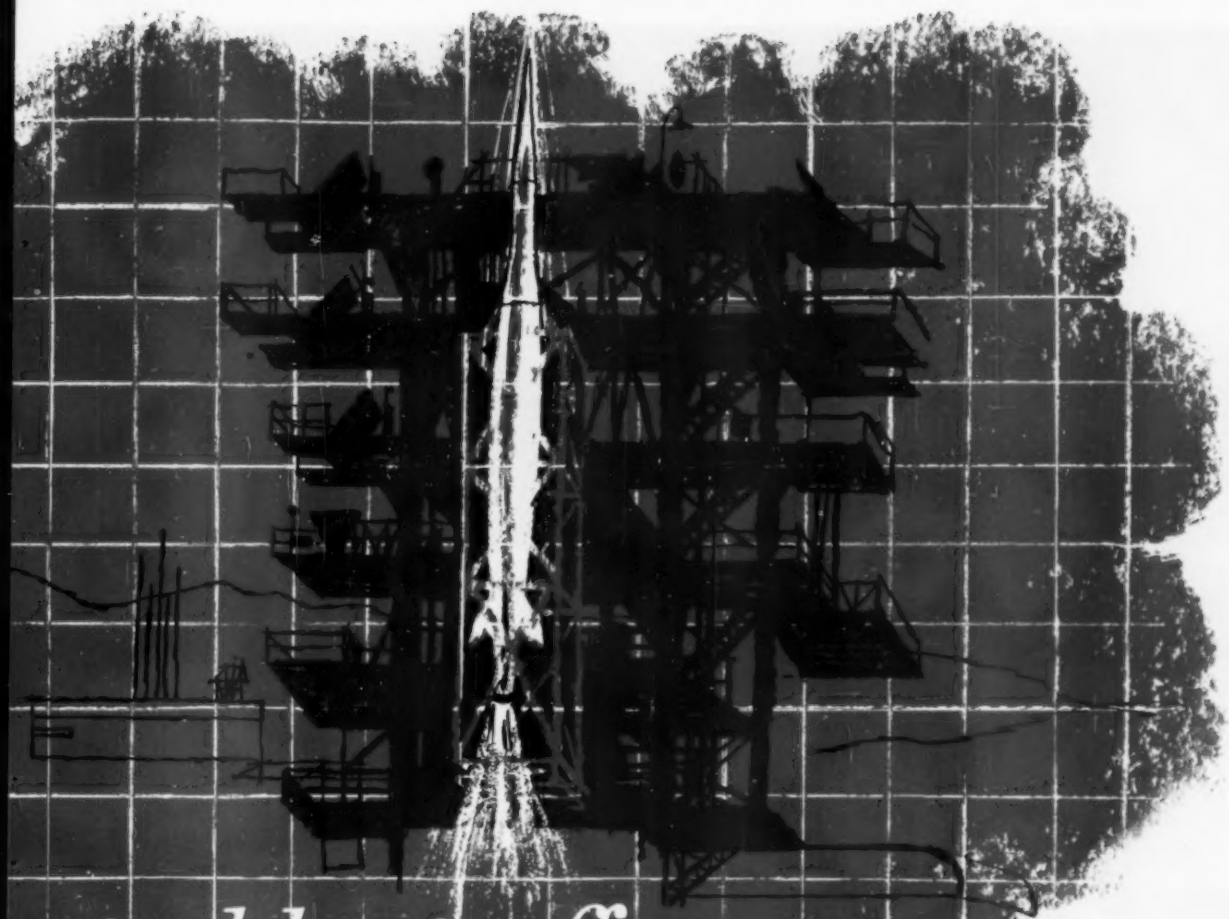
Others include: Nuclear instrumentation systems; Standard and custom-produced connectors for weapons and missile applications; Chemical warfare counter-measure devices; Specialized gas-discharge triggering devices and guided missile electronic components.

Wind tunnels, in a choice of size, velocity and configuration, for aerodynamic research and testing, are standard as well as custom-design products of

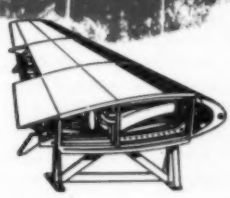
AEROLAB DEVELOPMENT COMPANY

Others include: Sub-sonic and supersonic target systems; Wind tunnels, Antenna, aero-elastic and flutter models; Precision prototypes; Electro-mechanical machinery; Liquid rocket engine power plants; Telemetry packaging; Radio-controlled servo systems.

U.S.HOFFMAN MACHINERY CORPORATION 103 FOURTH AVENUE, NEW YORK 3, N. Y.



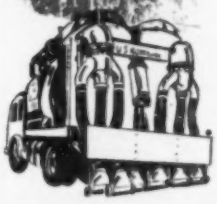
.....to blast-off



Outer wing panels and other components for military aircraft are just a portion of the production by a versatile organization.

INTERCONTINENTAL MANUFACTURING CO., INC.

In addition to the production of airframes and other major components, Intercontinental offers: Facilities for mass production; Two modern plants fitted with specialized equipment; Strategic inland locations at Garland and Brady, Texas; Excellent rail, road and air freight connections.



The Hoffman JARC* creates a 350 mph scrubbing velocity which thoroughly cleans jet aircraft runways of surface material that would otherwise endanger jet turbine blades and engines. Other air appliance and filtration engineering by the

INDUSTRIAL DIVISIONS, U.S.HOFFMAN

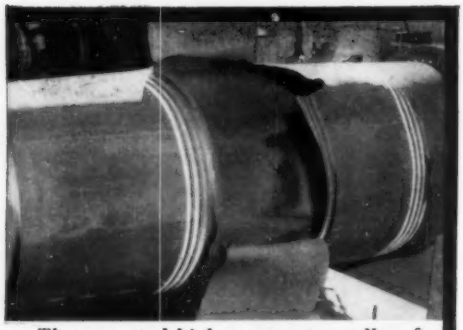
include: Multistage centrifugal blowers and exhausters; Stationary industrial vacuum cleaning systems and portable units; Pneumatic conveying and cleaning equipment for military explosives and radioactive materials; Unit and central systems for industrial filtration.

*T.M.

Hoffman is also a foremost producer of artillery shell and projectile for the armed services

New, highly advanced ramjet engines **designed and built by Marquardt Aircraft Company of Van Nuys, California, for supersonic missiles use Norton Rokide "A" spray coating. The Rokide coating aids in assuring successful flight by greatly increasing the resistance of the tailpipe to excessive heat and abrasion.**

Norton ROKIDE* coating plays vital role in Supersonic missiles



The uncoated high temperature alloy of this ramjet engine tailpipe failed during an especially severe testing in 14.2 seconds. Metal temperature exceeded 2200°F.

Coated with Rokide "A" on the forward portion only, an identical tailpipe was tested for 18.3 seconds without failure. Maximum metal temperature was 1800°F.

ROKIDE "A" aluminum oxide coating is one of three Norton refractory spray coatings — including ROKIDE "ZS" zirconium silicate and ROKIDE "Z" stabilized zirconia — now being widely used in modern high temperature applications.

In reaction motors and in various AEC projects, for example, the high melting point and low thermal conductivity of ROKIDE "A" coating reduces the temperature of the underlying material and permits higher operation temperatures. It is both thermally and electrically insulating, and its hardness, chemical inertness and stability in combustion temperature provide high resistance to excessive heat, abrasion, erosion and corrosion.

ROKIDE "A" Coating vs. Stainless Steel

While less dense than stainless steel, ROKIDE "A" coating is about five times as hard, has a considerably higher melting point and is very much lower in thermal conductivity and thermal expansion. ROKIDE coatings are applied in molten state with a metallizing type spray gun. Coatings may be applied to parts of all sizes and shapes accessible to the spray gun equipment. For further facts on ROKIDE coatings write to NORTON COMPANY, New Products Department, 744 New Bond Street, Worcester 6, Massachusetts.

Facilities for applying ROKIDE coatings at Worcester, Mass. and NORTON COMPANY, 2555 Lafayette Street, Santa Clara, California.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON
NEW PRODUCTS

NORTON PRODUCTS:
Abrasives • Grinding Wheels
Grinding Machines • Refractories
BEHR-MANNING DIVISION PRODUCTS:
Coated Abrasives • Sharpening Stones
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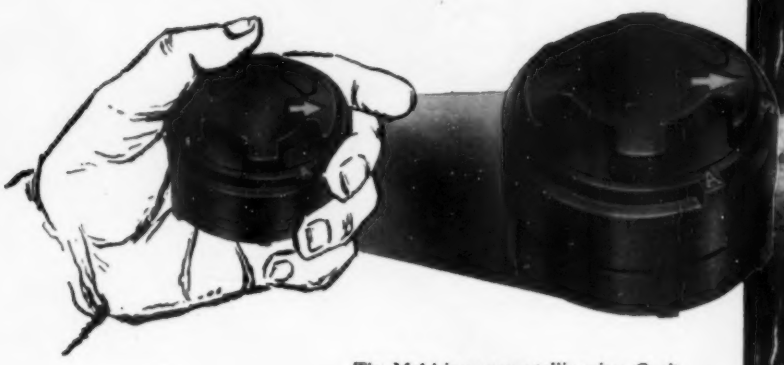
Making better products . . . to make your products better

PERRY PLASTICS HELPED DEVELOP PROCESS THAT CUT LAND MINE COSTS BY 50%, UPPED QUALITY



The M-14 is a nonmetallic mine. Can't be located by magnetic detector.

Looks harmless, doesn't it; for all the world like an earphone? But not quite. It's a tiny land mine. Anti-personnel mine, the Army calls it. Just by stepping on it, a man can lose a hand or foot. They were developed for the Korean war and used in large quantities.

Anti-personnel mines have come a long way since World War II. Then, they weighed 9 pounds, cost the Government $13. Thanks to plastics these mines now cost $2.50 and weigh 1/36 as much as their cast iron predecessor. More than that, they're nonmetallic and can not be located by a magnetic mine detector Being light in weight they can be laid quickly. Even in withdrawal there's usually time to scatter the mines over a large area, thereby taking a heavy toll of the pursuing enemy.

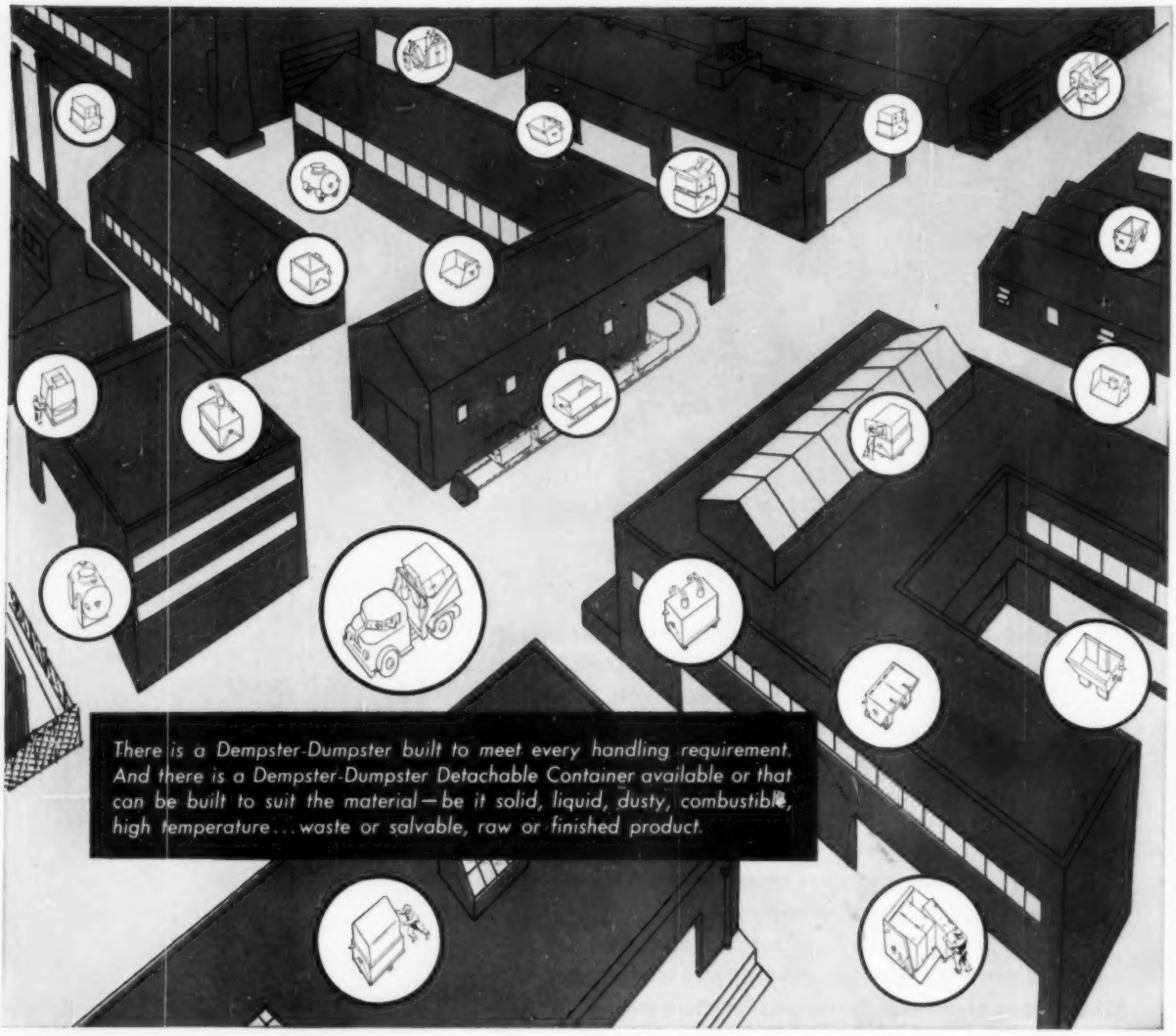
This is just another example of Perry's immense capacity for engineering and production skill. Maybe you have a production problem, some area in your process or component parts where plastics can help. Why not let Perry have a look at it? If plastics will do it, Perry Plastics will do it better. Get the story today.

U. S. Army Ordnance sequence photos show detonation of plastic anti-personnel mine. Note the pattern, confined and unidirectional—upward.

PERRY PLASTICS, INC.

ERIE, PENNSYLVANIA

Who else wants to reduce materials

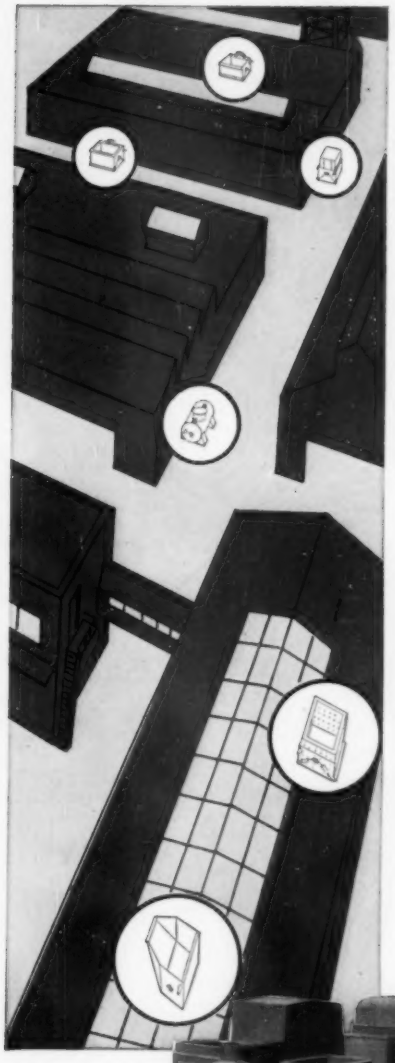


There is a Dempster-Dumpster built to meet every handling requirement. And there is a Dempster-Dumpster Detachable Container available or that can be built to suit the material—be it solid, liquid, dusty, combustible, high temperature... waste or salvable, raw or finished product.

With only one man, the driver, one Dempster - Dumpster serves scores of big detachable steel containers -- sizes 2 to 21 cu. yds... payloads up to 36,000 lbs!

SERVING COST-MINDED MANAGEMENT ALL OVER THE WORLD

handling cost 60% to 80% ? . . .



A FACT-FINDING SURVEY made by one of our engineers in cooperation with officials at one relatively small plant revealed labor cost of that firm's then-present-method was $6,552.00 annually. Labor cost would be $1,160.00 with the Dempster-Dumpster System — a saving of $5,392.00 annually (82 cents out of each $1.00). Investment in our equipment would amount to $10,000.00. In less than two years the equipment would pay for itself from its own savings produced for the user.

Results of a survey at a larger plant revealed annual labor cost amounted to $64,119.00, and would be $23,304.00 with the Dempster-Dumpster System — a saving of $40,815.00 (63 cents out of each $1.00). On an equipment investment of $40,968.00, the system would pay for itself in one year. In 5 years it would save this company over $200,000.00!

How much can this equipment save you? We recommend a fact-finding survey. No obligation, of course. It is the best way we have found to help you determine what can be expected of this system in your own particular operation. Or, perhaps you would prefer to first receive complete literature, free on request. May we hear from you? *Dempster Brothers, Inc.*

One Truck-Mounted
Dempster-Dumpster Handles Scores
of Containers . . . All Designs . . . All Sizes

DEMPSTER BROTHERS, 957 Shea Building, Knoxville 17, Tennessee

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U.S.I. CHEMICAL NEWS

A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries

Greenleaf to Handle Market Development of Zirconium And Titanium for U.S.I.

William C. Greenleaf has been named Manager of Metals Development for U.S.I. and will be responsible for market development and sales of zirconium and titanium sponge, to be produced from U.S.I.'s two new plants now being built in Ashtabula, Ohio.

A recognized authority in the field of zirconium and titanium, Mr. Greenleaf presented three papers during the 1955 Atomic Industrial Forum Zirconium Program, describing (1) melting of zirconium, (2) fabrication of zirconium, and (3) zirconium mill products and prices. He also conceived and developed processes now in general use for producing both wide-sheet and flat-bar titanium and zirconium by continuous strip-mill techniques.

Faye Named Manager of Sodium Product Sales

Martin Faye has been named Manager of Sodium Product Sales for U.S.I. and will be responsible for coordinating sales and sales promotional activities for metallic sodium, "U.S.I. Isosebacic" acid and related products.

Mr. Faye joined the U.S.I.-National Distillers organization in 1952 in the Market Research and Development Department.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing the Editor, U.S.I. Chemical News.

A zirconium-copper alloy now available is reported to combine high electrical conductivity with good strength retention at elevated temperatures. Suggested for electrical motor commutators serving above 500°F where strength is needed. Conductivity is 95.8% of copper. **No.1183**

Titanium wire cloth is now on the market in sizes from 60 mesh to coarser grades. It is reported to be particularly suitable for filtering or screening highly corrosive materials. **No. 1197**

Zirconium and Titanium Lick Roughest Corrosion Problems

Metals to be Available at Lower Cost in Future; Provide Long-Lived Materials of Construction; Complement Each Other on Corrosion Resistance

It is now practical to fabricate equipment which is *corrosion-resistant to almost every substance encountered in industry*, by using either zirconium or titanium metal. Alloys of either metal, or possibly both, may extend the range even further.

Industrial applications of these metals have been hampered by two considerations: availability and price. Zirconium will shortly be produced at a rate sufficient to supply industrial needs, and titanium has been available to industry during the past two years. And it is expected that increased production of these metals during the next few years will result in significant price decreases.

Twelve to thirteen thousand tons of titanium were available in 1956 and present construction schedules indicate that the figure will rise substantially in 1957. U.S.I.'s new plant alone will add 5,000 tons to the annual production capacity by the end of the year. Zirconium will be on the market in quantity by mid-1957. When its new plant at Ashtabula, Ohio gets under way, U.S.I. will be able to supply 500,000 pounds or more per year to commercial users in addition to its Atomic Energy Commission commitments of 1,000,000 pounds per year.

New Metals Economical

Chemical process equipment can now be fabricated from titanium for a little over twice the price of stainless steel, and it is expected that in the future titanium equipment will be only 50-75% higher than stainless. Commercial grade zirconium equipment will probably be priced only 75-100% higher than stainless when volume production is reached.

Typical Corrosion Resistances* of Zirconium and Titanium

Corrosive Media	Metal Resistance	
	Zirconium	Titanium
Sulfuric Acid	excellent to good below 80%	good below 5%
Nitric Acid	excellent	excellent
Hydrochloric Acid	excellent	good below 10%
Phosphoric Acid	excellent to fair below 85%	poor
Chromic Acid	excellent	excellent to good
Aqua Regia	poor	excellent
Wet Chlorine Gas	poor	excellent
Chlorine Water	excellent	excellent
Sodium Hydroxide	good below 90%	good below 50%
Ferric Chloride	poor	excellent
Calcium Chloride	excellent	excellent
Cupric Chloride	poor	excellent
Sodium Chloride	excellent	excellent
Ammonium Chloride	excellent	excellent
Aluminum Chloride	excellent	excellent to fair

*Above data do not cover all conditions because of space limitations. Literature references may be obtained by writing the Editor, U.S.I. Chemical News, 99 Park Ave., N. Y. 16, N. Y.

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keep the A.O.A. growing and receive as an award

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(two series of attractive and distinctive ordnance drawings for your home or office)

MAIL TODAY ▼

Just send in your recommendations. The Association does the rest and mails your A.O.A. Prints when four or more new memberships are obtained.

SEE DETAILS BELOW

A.O.A. PRINTS — SERIES I

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Print No. 2—The Gun Pit No. One
Print No. 3—Shell Factory No. One
Print No. 4—Forging Shells

A.O.A. PRINTS — SERIES II

"Early European Armament"

Print No. 1—The Trebuchet
Print No. 2—Turkish Bombard, 1453
Print No. 3—Swedish Regimental Gun, 1630
Print No. 4—Prussian Horse Artillery, 1759

(all prints measure 11 x 14 inches)

HOW TO WIN YOUR PRINTS

Simply jot down the names and addresses of your interested friends on the attached form and return it to Ordnance Association headquarters. We will send a membership invitation to each of those who are not now members, saving you the time and bother of contacting them.

When four of your recommended friends become A.O.A. members you may take your choice of a series of four A.O.A. Prints. Eight or more new memberships entitle you to a second series.

RETURN THIS FORM TODAY!

Here are the names and addresses of friends I think should belong to the Ordnance Association. Please send to each person listed, who is not already a member, a membership invitation telling him about the aims, purposes, and services of the A.O.A.

Please Print

NAME _____

Address _____

City, Zone, State _____

NAME _____

Address _____

City, Zone, State _____

NAME _____

Address _____

City, Zone, State _____

NAME _____

Address _____

City, Zone, State _____

NAME _____

Address _____

City, Zone, State _____

Please print *your* name here so that we may mention your name, and also give you credit for the memberships.

_____ **Your Name**

Return to:

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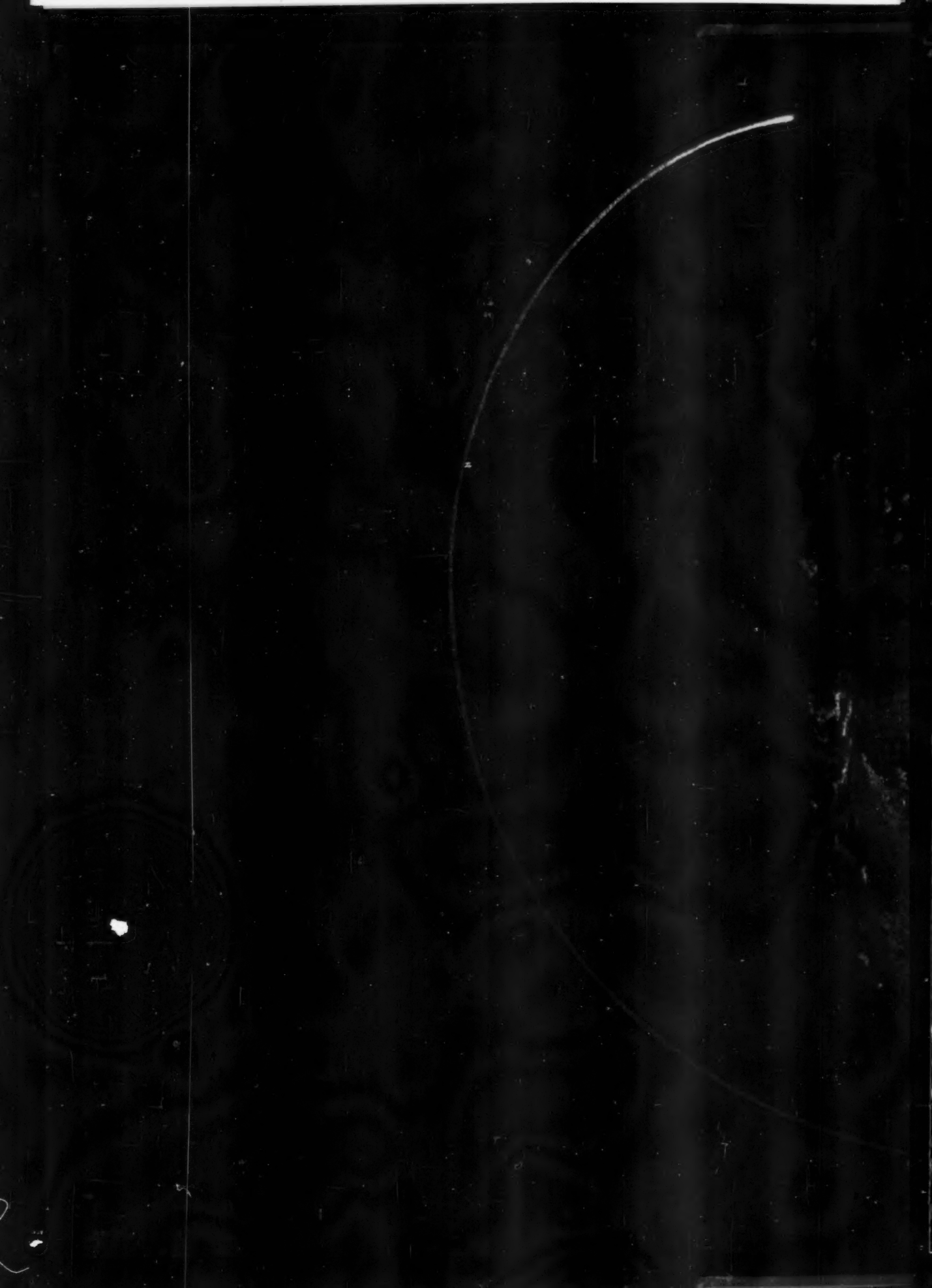
708 Mills Building, Washington 6, D. C.



FROM SEA LEVEL TO THE DARK EDGE OF OUTER SPACE
IS A ONE MINUTE FLIGHT FOR THE X–17 RESEARCH MISSILE
DEVELOPED BY LOCKHEED TO EXPEDITE USAF'S
LONG RANGE BALLISTIC MISSILE PROGRAM.

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• NUCLEAR PHYSICS • ADVANCED ELECTRONICS • HIGH-SPEED AUTOMATIC DATA REDUCTION • RAMJET PROPULSION TESTING •

Authority and Decision

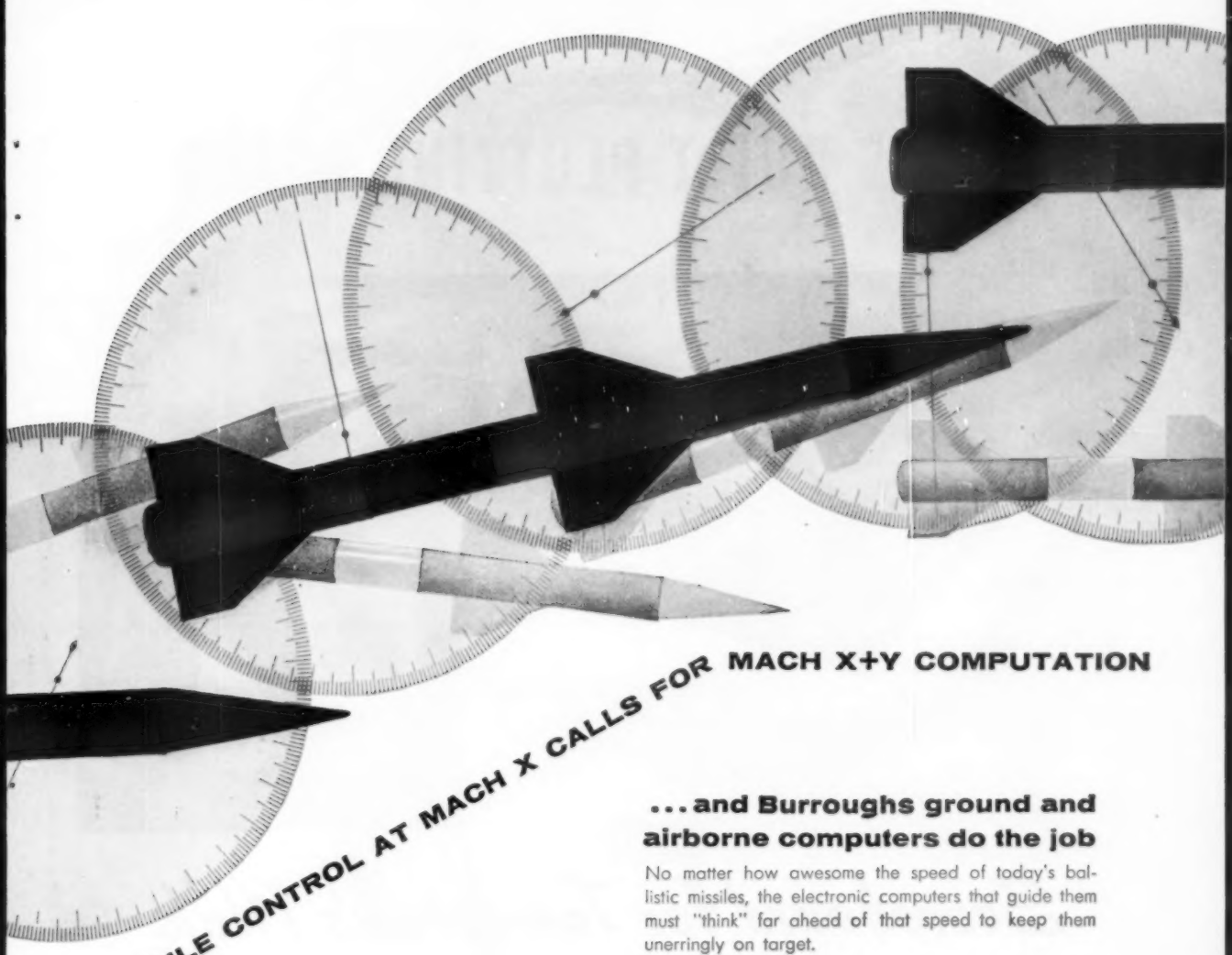
The most profound fact in the world today is that, in the final analysis, American ordnance is the basic safeguard of the free world.

Government and military leaders voice the same clear call—that every scientific and industrial help is wanted—and welcomed.

At this precise moment vast ordnance contracts are being assigned, new sub-contracts being placed, new industrial resources being added as our government continues at grips with this tremendous issue.

The magazine ORDNANCE serves a modest but vital purpose in this prolonged crisis. It delivers, with every issue, the one complete, concentrated audience of authority and decision—in government, industry and all branches of the Military Services.

ORDNANCE *The Basic Publication*



MISSILE CONTROL AT MACH X CALLS FOR MACH X+Y COMPUTATION

...and Burroughs ground and airborne computers do the job

No matter how awesome the speed of today's ballistic missiles, the electronic computers that guide them must "think" far ahead of that speed to keep them unerringly on target.

This sort of instantaneous computation is a Burroughs speciality . . . which is why ours is the major responsibility for the research and development of a guidance phase of the U.S. Air Force Ballistic Missiles program (a program embracing ATLAS, TITAN and THOR).

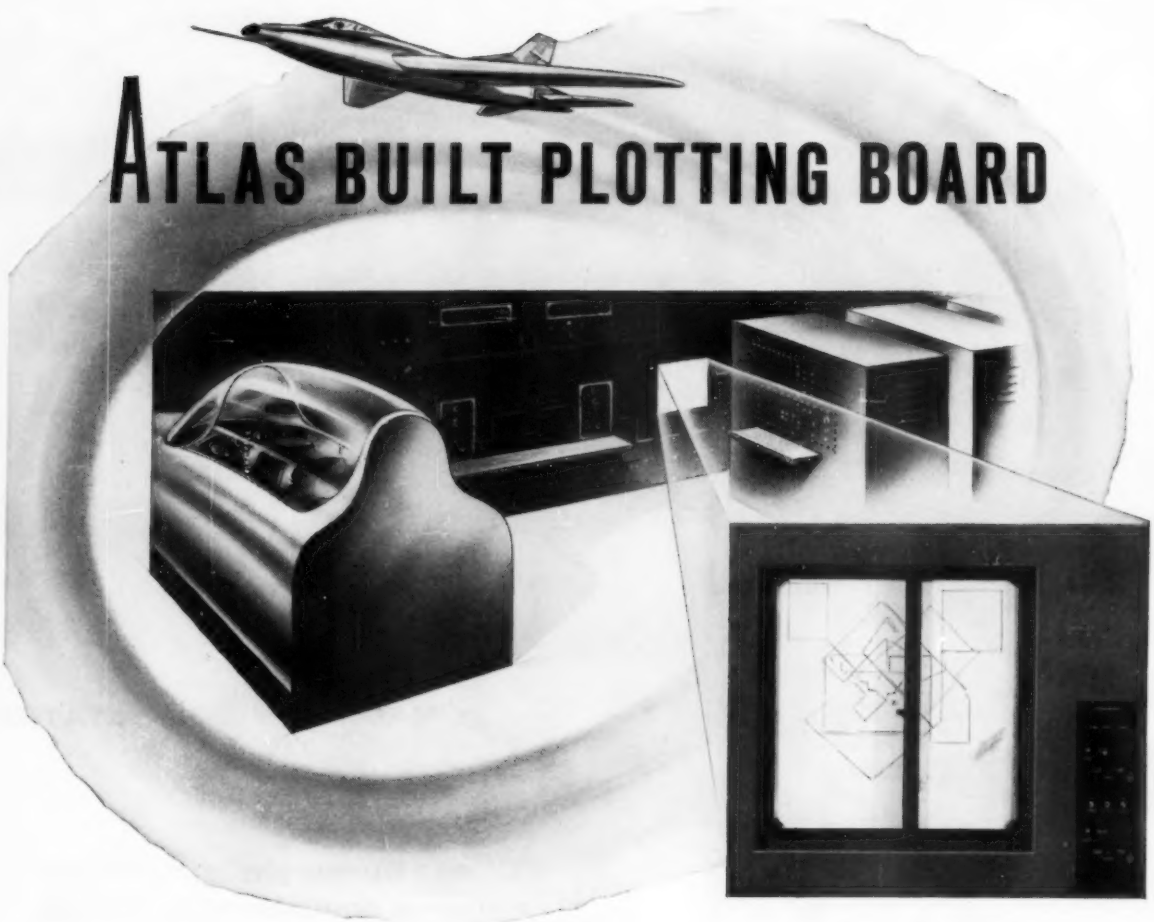
We have the proved resources and capabilities for further research and development of even more advanced ground *and* airborne computers. And as to reliability—Burroughs has unfailingly delivered on every defense contract undertaken. Not only in electronic computation but in control systems, instrumentation, communications, data processing and others.

In all areas of our proved responsibility and competence, in fact, Burroughs stands ready to see defense contracts through every step, from research to installation and maintenance. Write, call or wire Burroughs Corporation, Defense Contracts Organization, Detroit 32, Mich., or Burroughs Defense District Offices: Paoli, Pa.—392 W. First St., Dayton, Ohio—17071 Ventura Blvd., Encino, Cal.—1739 "H" St. N.W., Washington, D.C.

BURROUGHS

THE FOREMOST NAME IN COMPUTATION

ATLAS BUILT PLOTTING BOARD



Scoreboard For Tomorrow's Pilots

THE plotting board designed by Melpar Inc.—scoreboard of the new U.S. Air Force supersonic simulator for F-100A planes—is another example of Atlas manufacturing ingenuity at work.

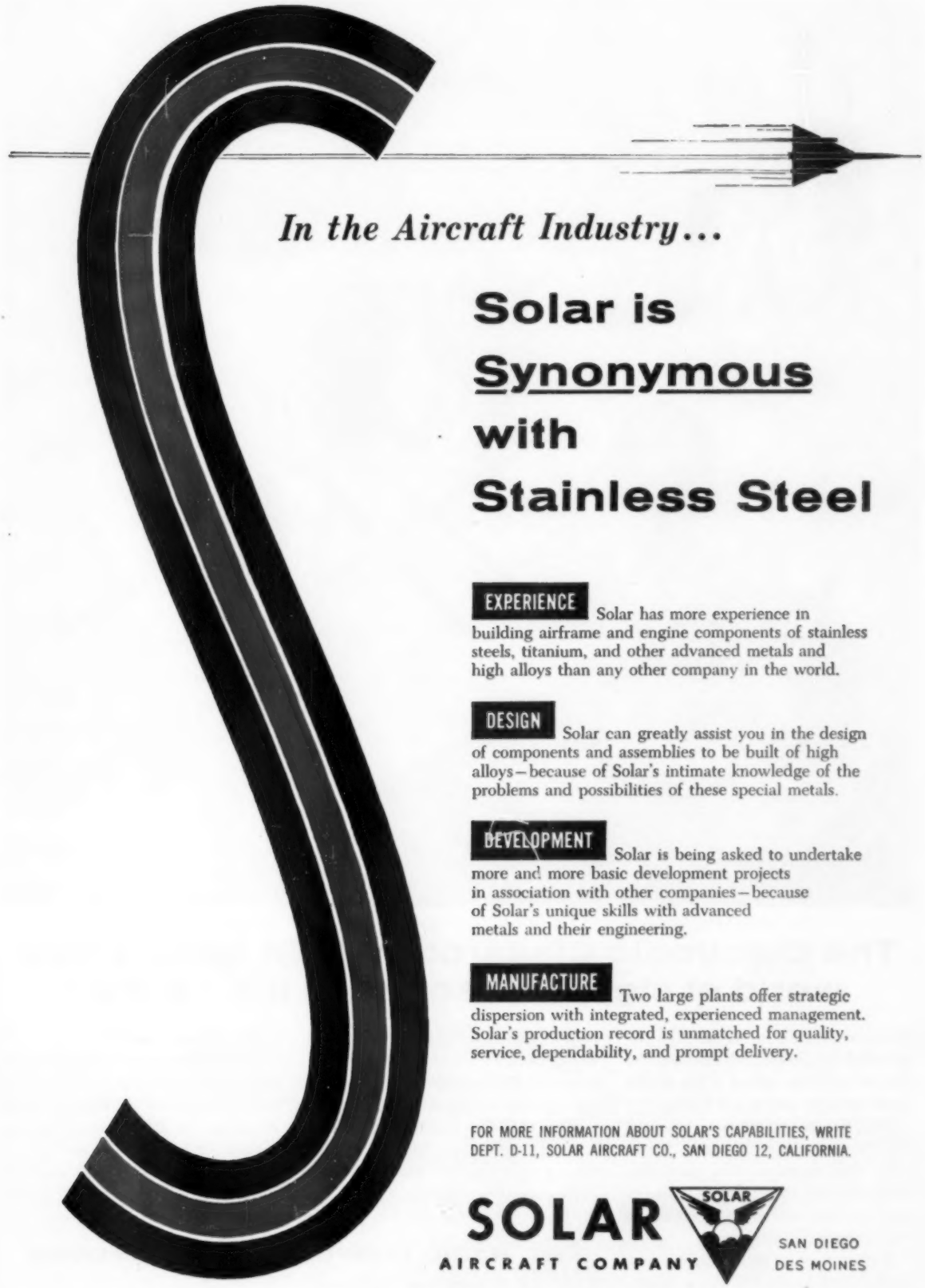
Atlas specializes in "precisioneering" electro-mechanical assemblies from the pilot stage to production efficiency. Furnishes the practical engineering step and the facilities between the idea and the production line.

Bring your electro-mechanical designs to us. Our design, production and methods engineers, tool makers and skilled mechanics are ready to work on your project on a job basis . . . as many men, machines and hours of work it requires and no more. Every modern tool and cost cutting technique is at your service to save you time and labor on a complete electro-mechanical assembly or a special part for electronic equipment. Write today for your copy of "Precisioneering Electro-Mechanical Equipment." ATLAS PRECISION PRODUCTS CO., Philadelphia 24, Pa. (Div. Prudential Industries).

"From Drawing Board . . . to Production Line"

SERVICE ATLAS DEPENDABILITY QUALITY

ATLAS
Precision Products



In the Aircraft Industry...

Solar is Synonymous with Stainless Steel

EXPERIENCE Solar has more experience in building airframe and engine components of stainless steels, titanium, and other advanced metals and high alloys than any other company in the world.

DESIGN Solar can greatly assist you in the design of components and assemblies to be built of high alloys—because of Solar's intimate knowledge of the problems and possibilities of these special metals.

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MANUFACTURE Two large plants offer strategic dispersion with integrated, experienced management. Solar's production record is unmatched for quality, service, dependability, and prompt delivery.

FOR MORE INFORMATION ABOUT SOLAR'S CAPABILITIES, WRITE DEPT. D-11, SOLAR AIRCRAFT CO., SAN DIEGO 12, CALIFORNIA.

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Designers, Developers and Manufacturers • Gas Turbines • Aircraft and Missile Components • Bellows • Controls • Coatings • Metal Alloy Products

The Electronic Classroom–RCA adds a new world of sight and sound to the "3 R's"

Today's classroom is no longer bounded by books and blackboards. For our children, school is big as the world of sight and sound itself.

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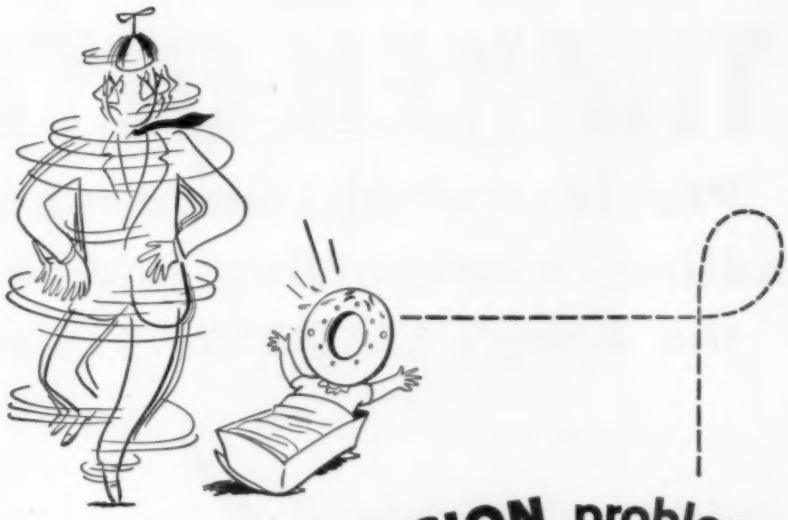
Even toddlers watching television at home get fascinating "lessons" in history, geography, the weather, world news, ballet, literature... The applications are endless.

Through its leadership in electronics, RCA contributes a great deal to the success of this new and broader kind of education. In fact, helping our oncoming generation to see, to hear... to understand... is one of the most important jobs we do. TMK(S) ®

RADIO CORPORATION OF AMERICA
Electronics for Living



a FRETTING-CORROSION problem had him in a spin

Finding a wear-resistant coating for turbine engine shaft seals posed a serious problem for an aircraft engine manufacturer. Even the hardest alloys were subject to fretting corrosion and had to be replaced after a few hours of service.

This fretting-corrosion problem was solved by having the bearing surface of the seal Flame-Plated by LINDE. By this special detonation process, particles of tungsten carbide are literally *blasted* onto almost any metal surface. Most important, the temperature of the part being plated never exceeds 400° F., so there is little chance that the base metal will warp or that its metallurgical properties will be changed. Flame-Plated tungsten carbide coatings can be applied in thicknesses from .010 to .002 inches. Coatings can be used in the as-coated condition (125 microinches rms) or ground and lapped to a 0.5 microinch finish.

If your design involves metal parts subject to extreme wear, heat, or fretting corrosion, perhaps Flame-Plating can eliminate some or all of your "headaches"—or make possible some completely new idea.

To find out, write us about your wear problem or request a free copy of LINDE's booklet, "Flame-Plating," F8065. Address Flame-Plating Department.

Flame-Plating *by* Linde

LINDE AIR PRODUCTS COMPANY

A Division of Union Carbide and Carbon Corporation

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From drawing board to firing line ...

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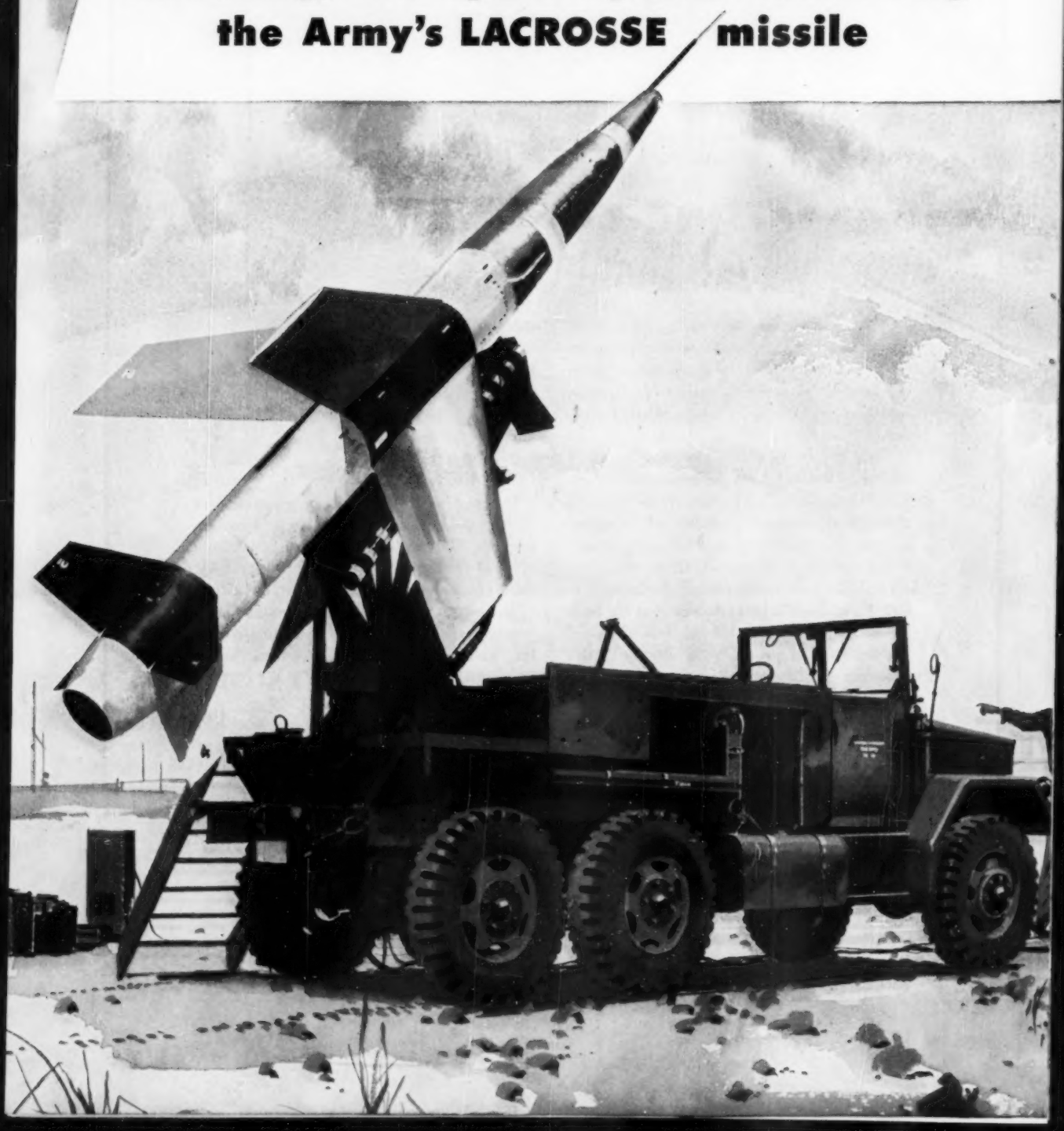
Provides vital components for handling, transporting and launching the Army's LACROSSE missile



TDA® offers to designers and builders of handling, transporting and launching equipment almost 50 years' experience in supplying power transmission systems for all types of military vehicles!

For nearly half a century, Timken® has been engineering and producing better-built axles, brakes and gear boxes for the Armed Forces. And today, Timken is devoting its vast experience and facilities to the design, development and manufacturing of these components for this nation's modern defense weapons.

Timken-Detroit pioneered the development of multi-wheel drives. Working with prime contractors and the U.S. Department of Defense, TDA has developed and manufactures a widely diversified line of military driving assemblies . . . standard military production items that can be assembled in any combination to make driving units for four, six or eight-wheel vehicles...and component parts for these assemblies are already available through world-wide military supply systems.

If you are a designer or builder of Missile or Rocket handling, transporting and launching equipment—Timken engineering experience and facilities are at your disposal. TDA engineers will work with you to solve any problem in power transmission. They will help you find the answer quicker, easier.

Plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York
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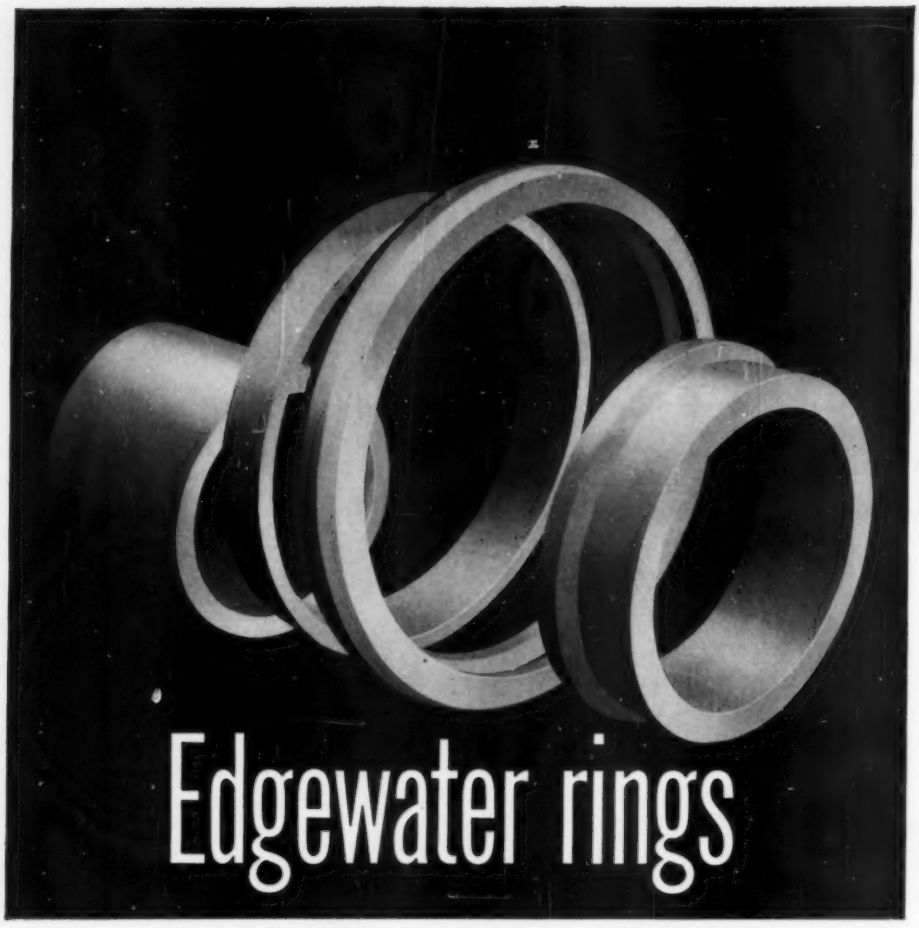
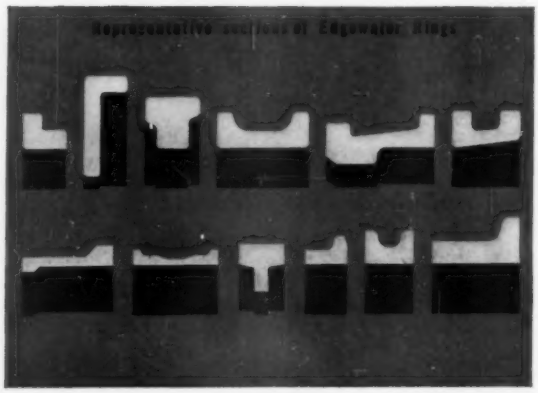


save critical materials . . . reduce costly machining . . . meet highest quality standards

for ordnance equipment

jet engines
aircraft
missiles

Your most critical specifications can be met by Edgewater Steel Rings—welded or weldless as required by the service. Formed accurately by modern methods, they are close to finish size as rolled. Weldless rings are rolled from solid steel blocks, in diameters from 5 to 145 inches. Welded rings up to 48 inches in diameter are formed from bars extruded or rolled to shape. Both types can be made in a great variety of sizes and cross-section shapes, as shown at the right. Being accurate in size and cross-section, Edgewater Rings save costly material and machining time.



Edgewater Steel Company

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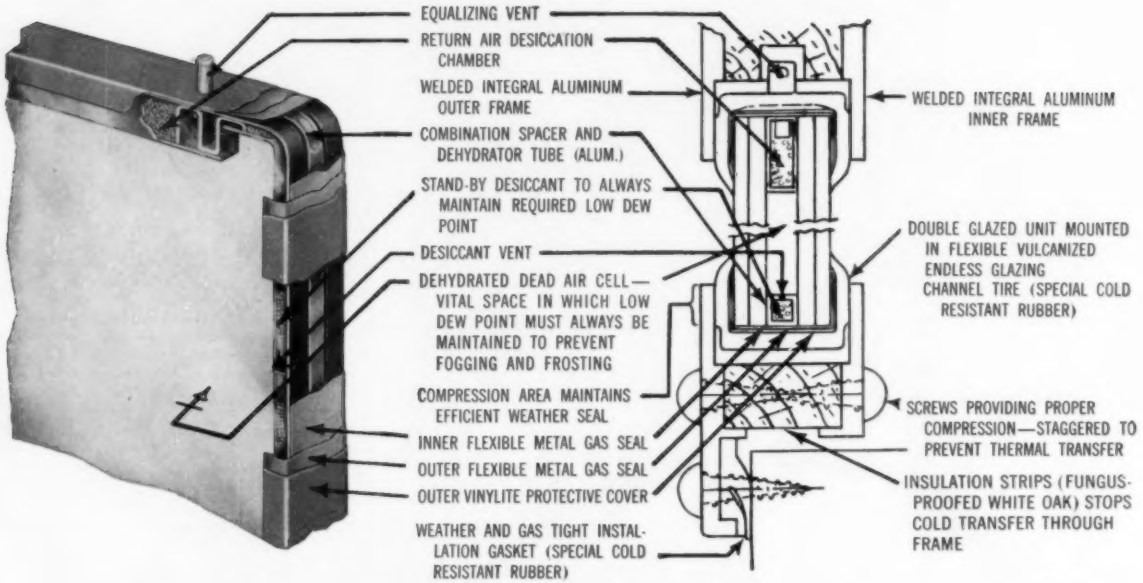
HIGH EDWARDS ALTITUDE


EQUALIZING VENT
RETURN AIR DESICCATION CHAMBER
WELDED INTEGRAL ALUMINUM OUTER FRAME
COMBINATION SPACER AND DEHYDRATOR TUBE (ALUM.)
STAND-BY DESICCANT TO ALWAYS MAINTAIN REQUIRED LOW DEW POINT
DESICCANT VENT
DEHYDRATED DEAD AIR CELL—VITAL SPACE IN WHICH LOW DEW POINT MUST ALWAYS BE MAINTAINED TO PREVENT FOGGING AND FROSTING
COMPRESSION AREA MAINTAINS EFFICIENT WEATHER SEAL
INNER FLEXIBLE METAL GAS SEAL
OUTER FLEXIBLE METAL GAS SEAL
OUTER VINYLITE PROTECTIVE COVER
WEATHER AND GAS TIGHT INSTALLATION GASKET (SPECIAL COLD RESISTANT RUBBER)
WELDED INTEGRAL ALUMINUM INNER FRAME
DOUBLE GLAZED UNIT MOUNTED IN FLEXIBLE VULCANIZED ENDLESS GLAZING CHANNEL TIRE (SPECIAL COLD RESISTANT RUBBER)
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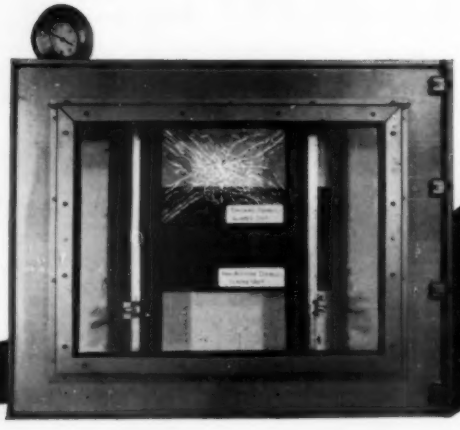
At All Altitudes
At Temperatures from +140° to −60° F.

EDWARDS High Altitude

meet severest service requirements for mobile air-borne units

HIGH ALTITUDE TEST

Demonstrates efficiency of pressure relief system, permitting the Edwards High Altitude Window to be taken to any altitude and returned to sea level at an ascent or descent rate up to 3000 f.p.m. without impairment of seal, bursting of glass or lowering of dew point in dead air space.



Window Assemblies

AIR FORCE CRASH TRUCK
Edwards windshield with heat resistant glass and regulator drop-type, **high-altitude** window assemblies.

MACHINE SHOP VAN
Edwards **high-altitude**, top-hinged, push-out window assemblies with insect screens and black-out shades.

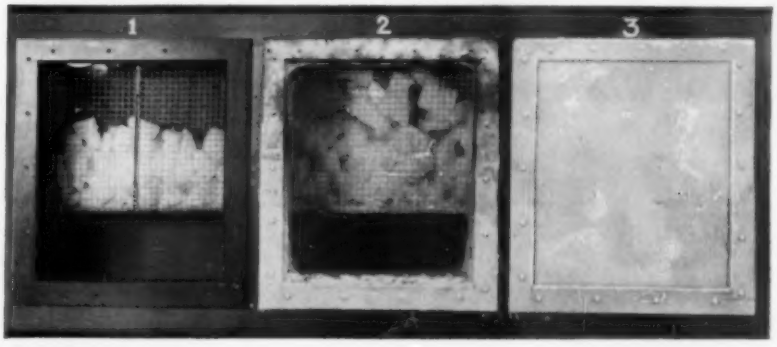
ARCTIC SNOW PLOW CARRIER
Edwards **high-altitude**, heavy-duty windshield (83 x 32) and drop-down window assemblies with regulators.

RADAR-ELECTRONIC SHELTER
Edwards top-hinged, pushout, **high-altitude** windows with inside insect screens and outside blackout shield.

Typical Service Applications

ARCTIC COLD TEST

Here is demonstrated the ability of the Edwards High Altitude Window to insulate against the transfer of heat and cold and provide clear visibility and light transfer at temperatures of —65°F. and lower. Photos left to right: Edwards High Altitude Window. Standard double-glazed non-insulated window. Single-glazed, non-insulated window. Results of these tests demonstrate and explain why the Edwards High Altitude Double-Glazed Window is widely specified by the armed services in all types of mobile air-borne equipment.



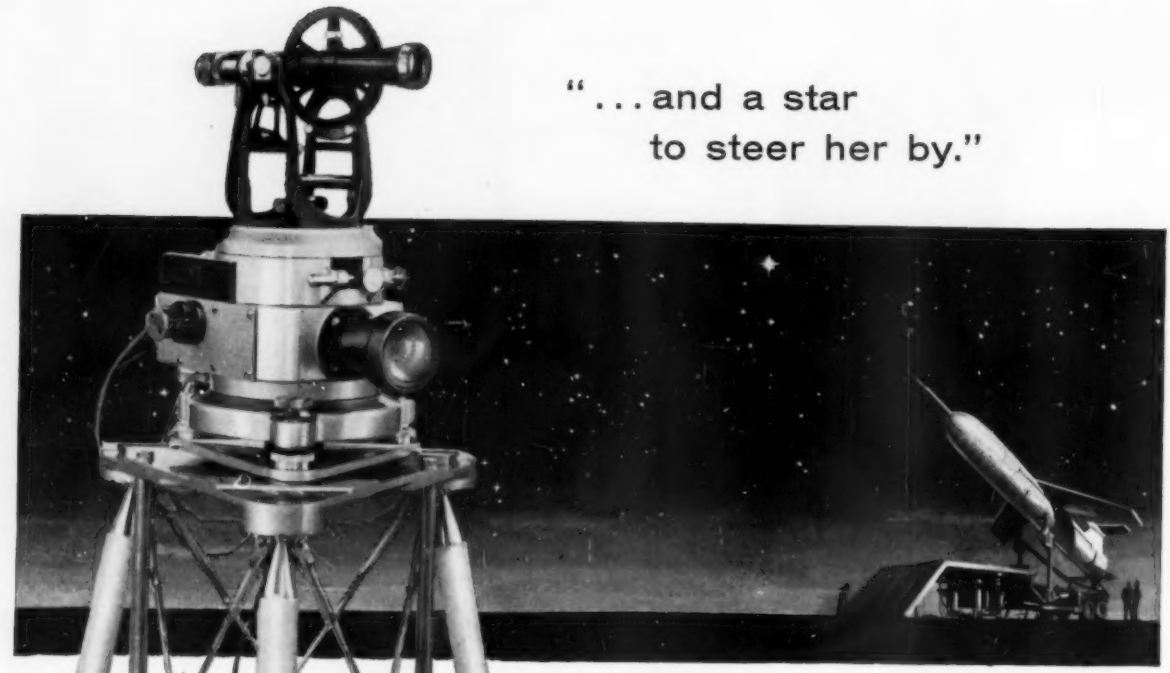
FOR COMPLETE INFORMATION:—

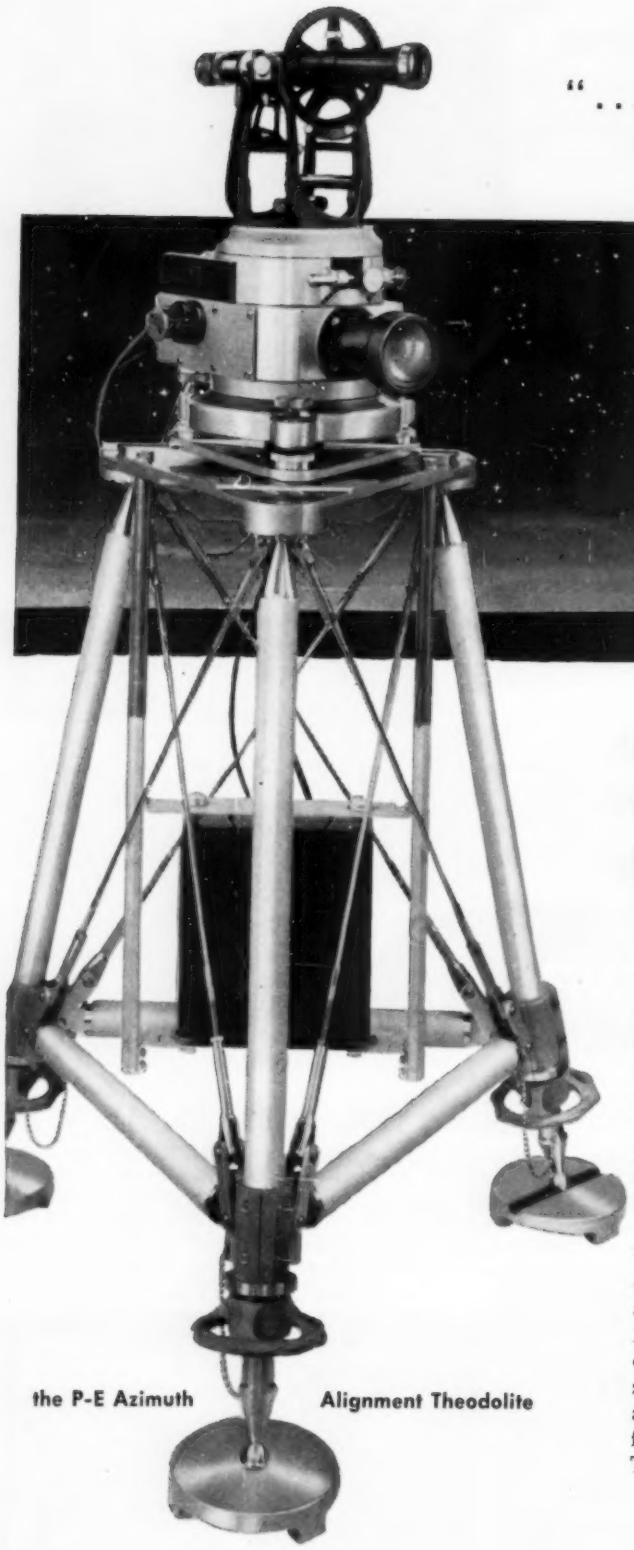
THE O. M. EDWARDS Company,
Syracuse, N.Y.

New York Office:
50 Church St., New York 7, N.Y.

THE EYES OF TRANSPORTATION

"...and a star
to steer her by."





the P-E Azimuth Alignment Theodolite

New Directional Accuracy for Automatic Navigation Systems

To give exact directional alignment to an automatic navigation system, the P-E Automatic Azimuth Alignment Monitoring Theodolite takes a "fix" on a navigational star and transfers the resulting angular data to the controlling mechanism. The accuracy of this astral bench mark to a great extent determines subsequent directional accuracy. *So precise is this instrument that it makes possible automatic alignment of the system to within a few seconds of arc under day or night conditions.*

Where extremely fine angular data must be established, the P-E Azimuth Theodolite offers a level of performance never previously available. Accuracy, as indicated by a "no correction" output of the monitored equipment, is ± 2 seconds of arc. Standard production models are available with working distances from 1 to 1500 feet. For further information on the Azimuth Theodolite, write to —

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NORWALK, CONNECTICUT

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	  ◦ Antennas
	  ◦ Beacons
	  ◦ Receivers
	  ◦ Transmitters
	  ◦ Pulse Circuits
	• Digital Computers and Data Processing
		• Gyro Development
		• Servo-mechanisms and Feedback Systems
		• Analog Computers
		• Military Specifications
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Do you dare tackle tough problems? At Ford Instrument Co., finding the answer to problems is the engineer's prime responsibility. As a result, the engineer who meets this challenge receives the professional and financial rewards his work merits. Our qualifications are high, and we want to be sure you can match the high standards of our present engineering staff. Our projects are too important and too complicated to trust to most engineers. What will you do at FICo? That depends on your specific abilities and experience. For details about the challenge, environment, and opportunity at FICo, write Philip F. McCaffrey at below address.

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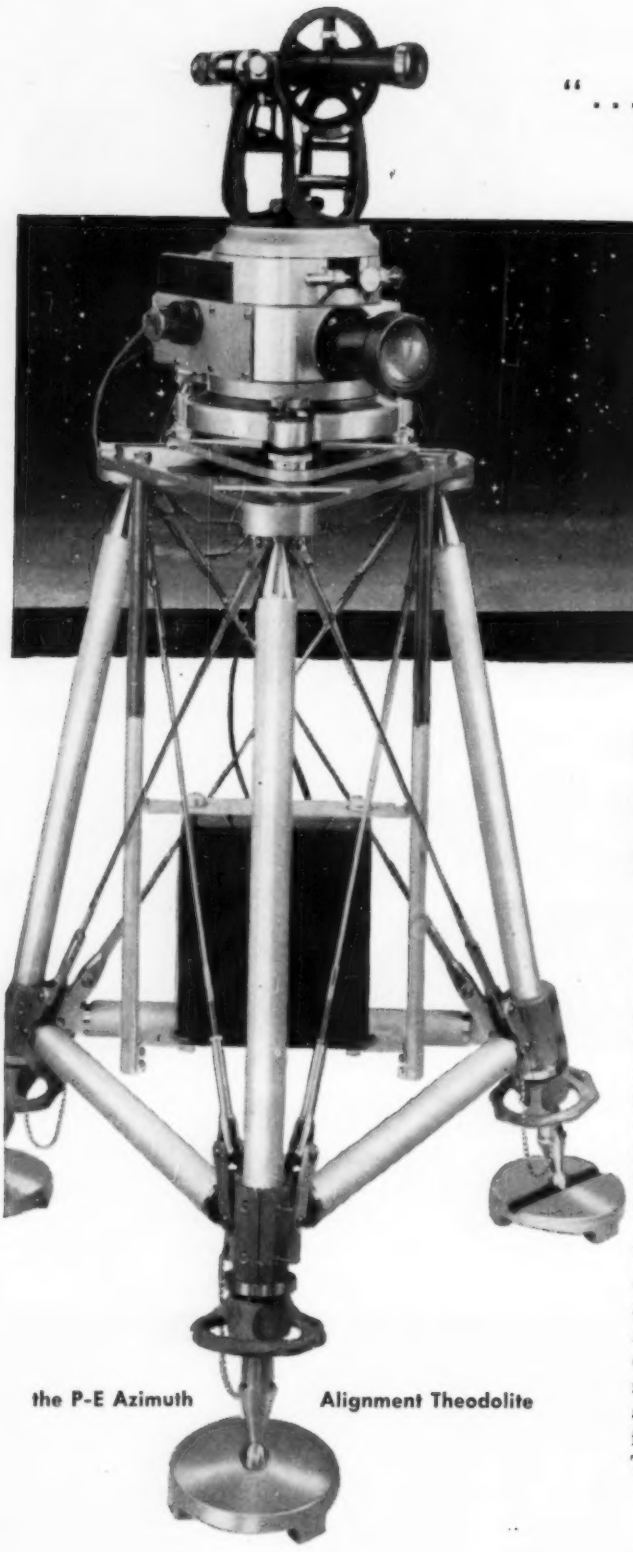
"...and a star
to steer her by."



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	• Military Specifications
	• Electronic Circuitry
	• Magnetic and Transistor Amplifiers
	• Network Design
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	• AC and DC Servo Motors
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		• AC and DC Servo Motors
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		• Missile Control Systems

MECHANICAL ENGINEERS with 2 or more years experience in:	• Inertial Guidance Systems • Gyro Development • Military Specifications • Servo-mechanisms • Product Design and Packaging of Electro-Mechanical Devices • Fire Control Systems	• Inertial Guidance Systems • Gyro Development • Military Specifications • Servo-mechanisms • Product Design and Packaging of Electro-Mechanical Devices
NUCLEAR ENGINEERS AND PHYSICISTS with experience in:	**NUCLEAR REACTORS** • Control • Metallurgy • Physics • Instrumentation	

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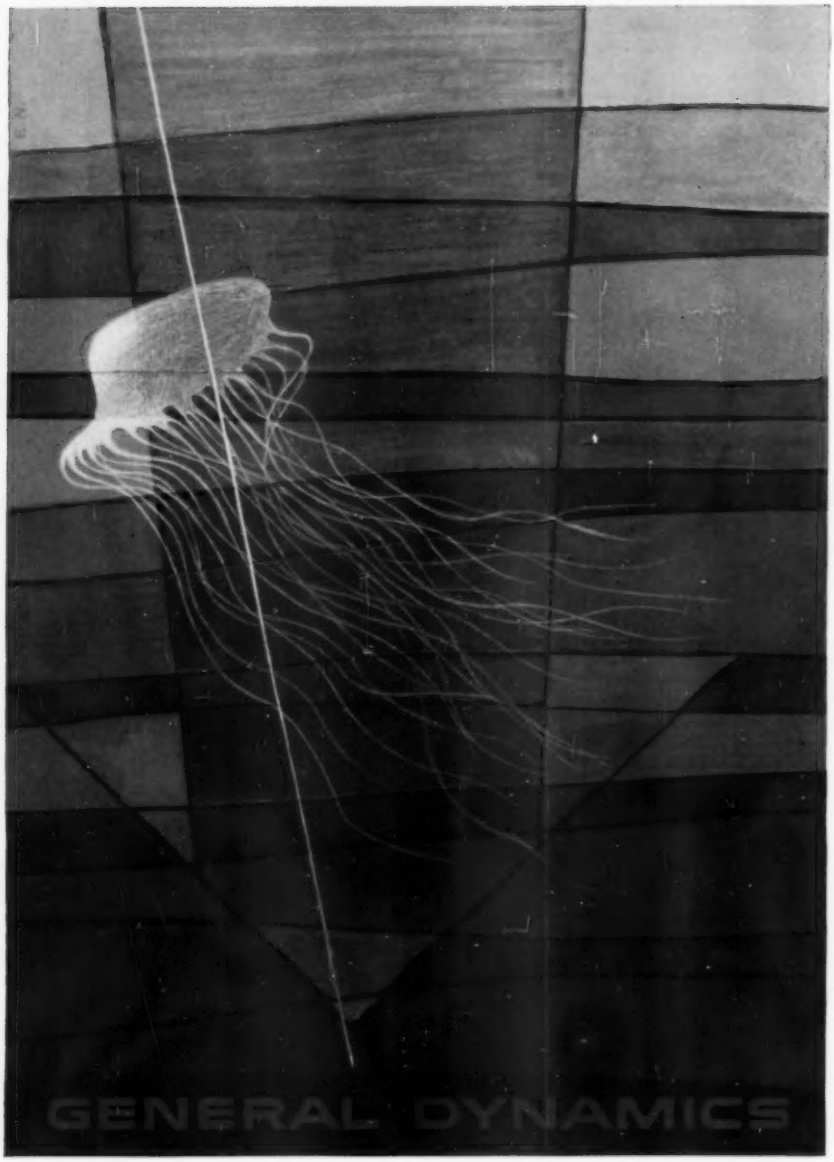

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In vessels
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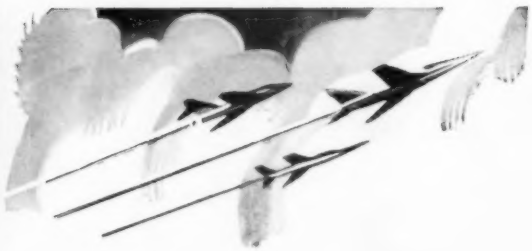
extract new minerals from
the mountains of, seek
new elements on the shelves
and beaches of,
herd new flocks to the grasses of,
draw new energies from the tides, the waves,
the atoms of,
the energetic sea.

the energetic sea



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A complete prototype service for the design and production of jet engine blades is ready to work for you at the Metals Processing Division of Curtiss-Wright. One of the most experienced blade producers in the industry – now turning out thousands of blades daily – the Metals Processing Division can contribute importantly at any stage of your operation . . . from blueprint through prototype . . . from processing of pilot quantities to full volume production.

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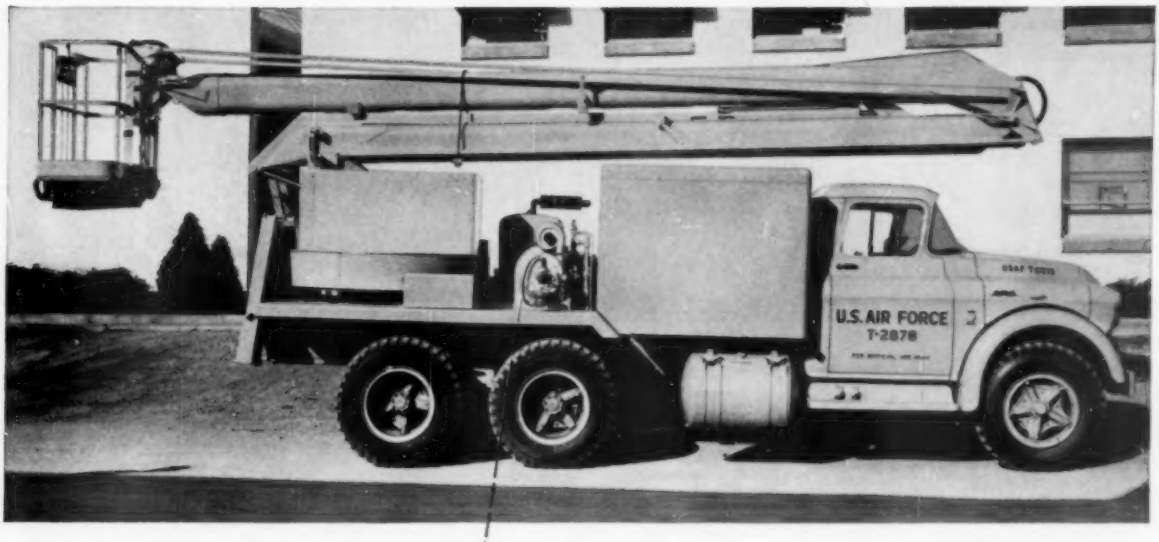
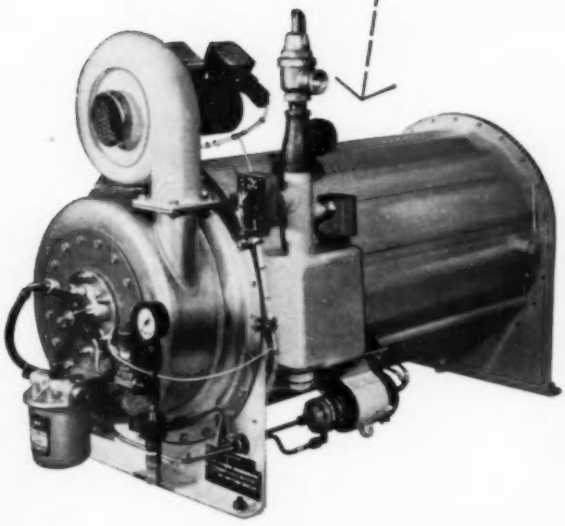


new Pitman ice-removal unit heated by Janitrol



When ice and snow cover ramp-parked aircraft, this new MB-3 Ice Removal vehicle strips away thick ice fast.

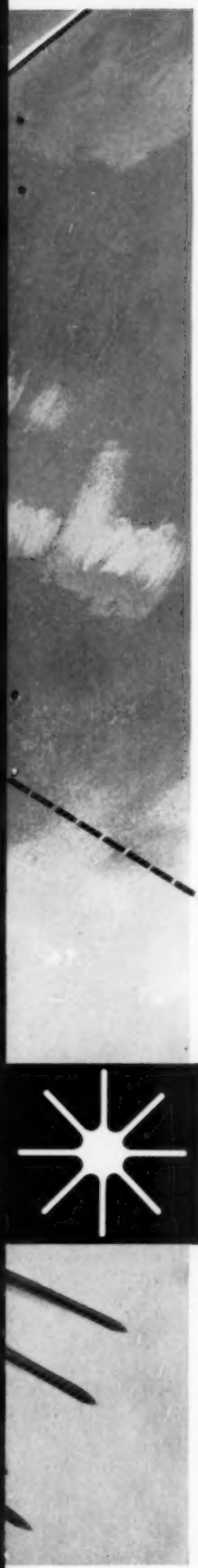
Operator on the extended boom can direct a spray of hot liquid against even the highest empennage. And for heating, the Pitman Manufacturing Company specified a Janitrol liquid heater, designed for a 10 gpm flow; 100° F temperature rise; 500,000 Btu/hr output.

The deicing fluid is automatically maintained at correct heat in a range from 180° to 200° F. Liquid recirculates continuously while the vehicle is in use, and discharge is through the heater at a maximum rate of 10 gpm when the sprays are turned on.

The Janitrol liquid heaters are available in a range of sizes from 90,000 Btu/hr to 750,000 Btu/hr . . . If you make ground handling equipment, vehicles for transport, crash trucks or fire engines—investigate Janitrol's line of liquid heaters for cargo or space heating. Janitrol heaters are in use right now from Thule to Byrd Station.

Janitrol

AIRCRAFT-AUTOMOTIVE DIVISION, SURFACE COMBUSTION CORPORATION, COLUMBUS 16, OHIO
DISTRICT ENGINEERING OFFICES: WASHINGTON, D.C., PHILADELPHIA, COLUMBUS, FT. WORTH, HOLLYWOOD



Navy's latest fire-power rides on this Flynn extrusion

The critical aluminum hanger beams supporting the new Aero 7-D rocket launchers are Michael Flynn extrusions. Nearly 50,000 of these vital parts have already been delivered for use on Navy jet fighters such as the Banshee and the Cutlass—parts that carry the payload that carries the punch.

Real quality in aluminum extrusions reflects not only advanced metallurgical engineering, precision die-making, and skill in press handling—but also the *reputation* of the extruder for delivering production quantities according to specification and *on schedule*. Twenty years' experience in quality metalworking has given Michael Flynn Manufacturing Company that reputation.

Flynn offers a wide range of stock profiles, one of which may well suit your needs. Also, take advantage of Flynn's facility in handling custom orders of every size. Close adherence to high standards sets Flynn extrusions above the crowd. *Ask Flynn first.*

MICHAEL FLYNN MANUFACTURING COMPANY
Extrusion Division

700 EAST GODFREY AVENUE, PHILA. 24, PA. ..... Tel.: FIdelity 2-5500
51 EAST 42ND STREET, NEW YORK 17, N. Y. ..... Tel.: MUrray Hill 2-0625
937 RADCLIFFE ROAD, TOWSON, MD. ..... Tel.: VAlley 3-2090
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FLYNN
EXTRUSIONS

Your mark of Ordnance loyalty

A.O.A. INSIGNIA

Lapel Emblem

Lapel Bar

Ribbon Lapel Rosette

Available only to Association members, the official insignia will identify you as a loyal A.O.A. supporter, and a patriotic American. You'll want to wear the emblem, rosette, or bar on fitting occasions, and display the plaque and membership certificate in your home or office. Insignia are in the attractive ordnance colors—maroon and gold.

Indicate your preference below and return this form with your check to Association headquarters. Postage is prepaid to domestic destinations.

	Quantity Desired	*Amount*
Label Emblem (bronze), $1.50	.....	$.....
Lapel Bar (bronze), $1.00	.....	.....
Ribbon Lapel Rosette, $1.00	.....	.....
The Medal (bronze), $2.50	.....	.....
Wall Plaque (8"x9"), $3.00	.....	.....
Bar Ribbon, 50¢	.....	.....
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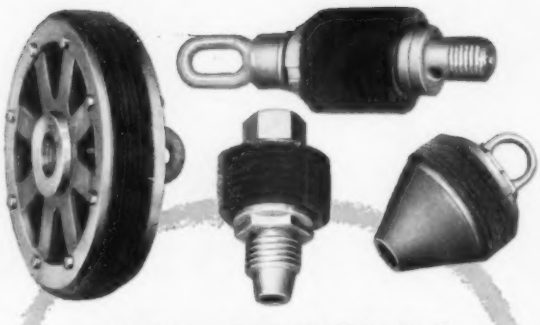

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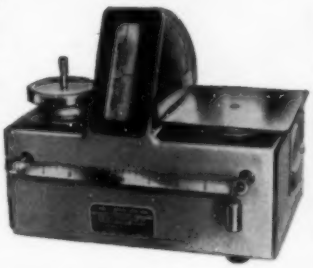

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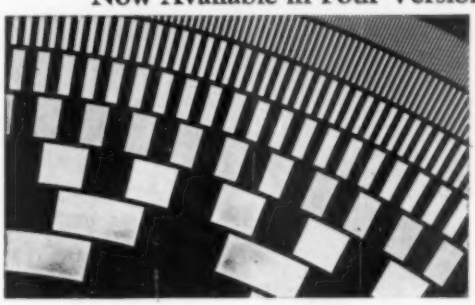

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ARMAMENT TECHNOLOGY

This section of ORDNANCE contains selected papers presented at meetings of Technical Divisions and Committees of the American Ordnance Association and contemporary articles on armament research, development, manufacture, and field use

The New Machine Gun

The 23-pound M60 is replacing the three caliber .30 Army weapons

T. E. Cosgrove

Engineer, Research and Development Division, Office, Chief of Army Ordnance, Washington, D. C.

A FEW years ago an article appeared in the *Reader's Digest* entitled "Farewell, My Lovely." This glamourous title actually was a eulogy for the Model T Ford and was so well written that it almost made one wish for the return of that venerable vehicle.

In a sense, the subject of these paragraphs concerns some Model T's of the small-arms field. It is doubted, however, that the U. S. infantryman will really yearn for the Browning guns after he has become familiar with the Army Ordnance Corps' new light machine gun.

The M60, the adoption of which was first announced on January 30, 1957, represents a significant advance in the development of small arms. The nature of this advance is apparent from a consideration of the fact that the new weapon will replace all three caliber .30 machine guns now in use by the Army —the M1919A4, the M1919A6 (both air-cooled) and the heavy machine gun, the water-cooled M1917A1.

IN other words, Army Ordnance is now providing a single weapon that will perform not only in the assault rôle but in those military situations where accurate, sustained fire may be required. These two requirements usually contradict each other, but the M60 machine-gun system eliminates the contradiction by the simple expedient of combining light weight, a quickly replaceable barrel and gas system, and the use of NATO-approved ammunition with cool-burning propellent powder.

Ordnance Corps efforts to develop a lightweight machine gun extend over a considerable period of time, beginning in the 1920's. Since then, many worthwhile mechanisms have been designed, built, and tested. In every case, however, the resulting weapons were superior in some, but not all, respects and therefore were not adopted as replacements for the existing Browning guns.

DURING World War I, static tactical situations called for two basic types of weapon—a heavy gun on a stable mount to provide long-range, direct or indirect fire from previously prepared positions and a lighter weight weapon for use during assault and to cover gaps in the fire lanes laid down by the heavier weapons.

Near the end of World War I, the recoil-operated Browning gun was beginning to make its appearance. Only a few saw service in France, but in the years after the Armistice this mechanism received most of the engineering attention of the Ordnance Corps.

At the beginning of World War II in Europe, Army Ordnance had available several types of caliber .30 machine guns for ground use. These included the water-cooled M1917A1 and the air-cooled M1919A4. The latter of these

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WEAPON			AMMUNITION		TRIPOD MOUNTS	
Model	*Weight (pounds)*	*Rate of Fire (rounds per min.)*	*Type*	*Velocity (ft./sec.)*	*Type*	*Weight (pounds)*
M60 (w/bipod)	23	600	NATO	2,750	M91	25
M1919A4	31	550 max.	M2	2,740	M2[1]	14
M1919A6	32.5	650 max.	M2	2,740	M1917A1[2]	53
M1917A1 (w/water)	41	600 max.	M2	2,740	M74[2]	29

1. The M2 mount is included for information only. This tripod normally serves the function of a bipod in the light machine gun rôle rather than for sustained fire.
2. The M74 mount also is used with recoilless rifles.
3. These three mounts can be used with the M1919A4, M1919A6, or M1917A1 weapons.

Comparison of the new M60 machine gun with the three standard caliber .30 weapons.

had been modified and lightened for aircraft use and was identified as Gun, Machine, Caliber .30, Browning, Aircraft, M2. For ground use, the M1919A4 was mounted on the M2 tripod for employment as a light machine gun.

With the advent of mechanized warfare in Europe during World War II, it became apparent that fluid situations required weapons substantially different than heretofore. Accordingly, the tactical branches of the Army coördinated a set of specifications for a light machine gun, and the Ordnance Corps was directed to proceed with the development of a weapon meeting the requirements.

It should be emphasized here that although the M2 aircraft weapon, weighing twenty-three pounds, was the lightest weapon then available, it did not, and does not today, meet the user requirement for a lightweight, general-purpose machine gun because of its high cyclic rate of fire.

In April 1940, the War Department issued a circular entitled "Information for Inventors Desiring To Submit a Light Machine Gun and Mount for Test by the War Department." This circular contained the specifications and other information of interest to inventors, designers, and firearms manufacturers.

Persons and firms that had shown an interest in the general subject were notified in advance that only completed guns would be eligible for consideration in the competition and that these must be ready by October 1941—eighteen months after the date of the announcement. Although sixty persons had shown an interest in the light machine gun, only six organizations, including two Ordnance arsenals, submitted guns.

Subsequent evaluation and testing were very discouraging—none of the guns met the specifications outlined in the circular, nor did they have possibilities far enough in advance of existing weapons to warrant consideration for adoption.

Since the United States was now in the war, the military characteristics were reviewed to determine what, if any, changes might be indicated by combat experience. The revised specifications included requirements for reserve power, quick-change barrel, bipod mount with tripod capability, and pistol grip and pull-type trigger. Additionally, reliability and ease of manufacture were stressed.

DURING the years of World War II, development continued both within the Ordnance Corps and with industry on contract. The following designs are the more noteworthy:

1. *T10* and *T23*.—Colt's Patent Fire Arms Manufacturing Company design based on the Browning automatic rifle, with design modifications proposed by Springfield Armory, Auto-Ordnance Corporation, and the High Standard Manufacturing Corporation.

2. *T24*.—A redesign of the German MG42 adapted for use with the caliber .30 M2 cartridge.

3. *Johnson light machine guns*.—Several weapons developed by Johnson Automatics, Inc., including the Model 1940, Model 1944, and the T40. The 1940 and 1944 models were magazine-fed, and the T40 was a further redesign to permit belt feeding.

The new M60 can be fired from the shoulder or hip, from its own bipod, or from a new aluminum tripod mount (Army photo).

4. *T33.*—Caliber .30 M2 aircraft machine gun equipped with bipod, rear sight, and shoulder stock.

None of these weapons was accepted for service use.

In 1942 the using arms again submitted a recommendation for additional effort on light machine gun development in accordance with established characteristics. As an interim measure it was recommended that the M1919A4 gun, equipped with a folding bipod and shoulder stock, be investigated. Although it was recognized that such an arrangement would not meet all the requirements for a true light machine gun, it was also recognized that the mechanism was dependable and rugged.

Testing of the modified guns was promising in that no parts breakages occurred and functioning was satisfactory. Changes recommended as a result of the tests included modifications to the stock and carrying handle as well as redesign of the muzzle booster cap to increase reserve power of the gun.

On February 17, 1943, this assemblage was standardized as Gun, Machine, Caliber .30, M1919A6. Firing tests of first production models resulted in the statement to Ordnance that functioning of the A6 gun was far superior to any other light machine gun tested.

The preceding statement explains why the M1919A6 was the Army's light machine gun for such a long period of time. This mechanism became the standard to which other designs were compared.

THE next major step in the development of a lightweight, general-purpose machine gun was the design of the T52 mechanism. For this work the Ordnance Corps called upon the Bridge Tool & Die Works, Philadelphia, Pa. Although this firm had no previous gun experience, it was considered that it could provide the necessary engineering talent. The work to be done by Bridge Tool & Die required the evaluation of certain gun mechanisms and the design and fabrication of an optimum weapon based on this evaluation.

Particular emphasis was placed on the MG42 and the FG42, both weapons of German design. The more important FG42 utilized metal stampings in order to achieve light weight and simplicity of manufacture. The FG42 aso utilized the rotating-bolt principle of the World War I Lewis gun. The T52 design was

Above, first model of the T52 light machine gun fabricated in 1948. Below, later design, the T52E3, replaced wooden parts of the earlier model with stamped metal components (Army photos).

Below, the final version of the light machine gun, the T161E3, was adopted as the M60 in January of this year. It will replace all three current caliber .30 machine guns. The weapon is shown on the M91 mount (Army photo).

modified several times through T52E5. The resulting weapon had the following features:

(1) Adapted for use with the "push-through" link, (2) Extensive use of formed sheet-metal parts, (3) The use of rubber covering on metal parts that must be handled to reduce heat transfer to the firer, (4) Fixed headspace permitting quick replacement of barrel and bipod assembly, (5) Gas expansion and cut-off system of operation, (6) A tripod for the sustained-fire rôle with low command height and no compromise to the required ranges of elevation and azimuth adjustment.

EXCEPT for the tripod, all the above features had been available in the prior art, but until the start of this program they had not been successfully combined into a single weapon meeting the requirements for ground use.

When it became apparent that the design features embodied in the work of the Bridge Tool & Die Works were sound and promised a workable machine gun, a parallel approach was initiated. This second approach was inaugurated to assure that a gun producible by mass-production methods would be available after completion of the development program.

For this phase of the work the Ordnance Corps relied upon the experience and capabilities of the Inland Manufacturing Division of the General Motors Corporation. The Inland version of the gun, designated T161E3, was the weapon selected for adoption and is now known as the M60.

Concurrently with the gun-development a program for the development of a tripod mount for the new gun was pursued. The mount finally selected for adoption was the T178E2 model development by the Bridge Tool & Die Works with the assistance of the Ballistic Research Laboratories at Aberdeen Proving Ground. The new mount, now standardized as the M91, for use with the M60 gun, is a lightweight aluminum mount of the soft-recoil type. ("Soft" in this sense means the gun recoils against springs to reduce shock and overturning moment transmitted to the tripod.)

The reason for its success lies in the fact that it presented a solution to a potentially difficult problem that arose during the early phases of user testing of the weapon system. This testing showed that when employed from the tripod in the sustained-fire rôle, the light machine gun's command height (distance from the ground to the center line of the barrel) was so great that the gunner would unnecessarily expose himself when setting or adjusting sights. The new tripod, to remedy this situation, provides adjustable command height with a minimum of twelve inches.

The adopted version of the M60 weighs 23 pounds, including the shoulder stock and the bipod, and is 43 inches long. The ammunition used is the NATO 7.62-mm. ("T65") cartridge assembled with M13 links. The cyclic rate is 600 rounds a minute. No provision is made for single-shot fire, although short bursts and single rounds can be fired by a trained gunner. The bolt is the rotary locking type similar to that used in the Lewis machine gun.

The barrel is air-cooled with the quick-change feature mentioned before. The barrel also includes the bolt-locking cams and the basic element of the gas system. Feeding is from the left-hand side with spent cases ejected to the right. The M13 link is the disintegrating, "push-through" type. Ammunition belts for this gun can be packed in conventional cans and boxes or they can be packed in a special container which clips to special brackets on the left side of the receiver. Such an arrangement will be especially useful in the assault rôle.

AN additional feature of this weapon is that it fires from an open bolt, thus eliminating the danger of cook-off. The bolt will close, however, if the trigger is held down until the belt of ammunition is exhausted.

In addition to the basic weapon itself, the light machine gun concept includes a bipod with adjustable legs. As will be observed from the photographs, each leg includes a perforated sheet-metal "skirt." These skirts serve two purposes. They stiffen the leg assembly, and they provide a handhold and heat shield when it becomes necessary to remove a hot barrel. The flash suppressor, the bipod, the front sight, and the gas system are replaced when the barrel is replaced.

For the sustained-fire rôle, the M60, *without modification,* is assembled to its aluminum tripod mount, the M91 (T178E2). This tripod is an adaptation of the "soft mount" type and was developed especially for the M60 gun.

"Soft mounting" for this machine gun was thoroughly tested both at Fort Benning, Ga., and at Fort Greely, Alaska, so that the Ordnance Corps and the Continental Army Command could be certain that the combination of light gun and light mount had adequate accuracy and stability characteristics for field use. The new mount weighs twenty-five pounds.

BASICALLY, the M60 is a gas-operated weapon. The gas system is assembled to the barrel in a manner that permits a predetermined quantity of gas to be bled off the barrel about 8 inches from the muzzle. This gas then expands against the hollow piston, cutting off the further supply of gas and moving the piston backward to contact the operating rod.

The operating rod is linked to the bolt and firing pin so as to rotate the bolt for unlocking and to cock the firing-pin spring during the early part of the recoil stroke. Also during recoil, rearward movement of the bolt actuates the feed mechanism, lining up a cartridge for feeding.

In counterrecoil, the right-hand locking lug strips a cartridge from the link and cams it into the chamber. When the bolt is fully locked, the firing pin can contact the primer and fire the round.

A principal advantage of the M60 machine-gun system is in the weight reduction with no sacrifice in performance over other weapons heretofore available. (See chart on p. 1096.)

Just as important as the reduced weight is the fact that the new gun can be used for sustained fire or for assault-type fire. Tests have shown the M60 to be capable of firing at a rate of 125 rounds a minute for a total of 5,000 rounds.

Additional important features include the use of roller bearings wherever possible to reduce friction and the extensive use of stamped parts to reduce costs and simplify manufacture.

One additional feature of this weapon —a requirement for all light machine guns—is a relatively slow rate of fire. High rates of fire in the antipersonnel rôle are substantially no more effective than low rates and usually result in decreased parts life and materially reduced accuracy.

Precision Measurement

Good progress has been made in producing an interferometric system which, by averaging a few observations, gives a precision of one ten-millionth of an inch as a standard for measuring gage blocks

Dr. Irvine C. Gardner

SOME time ago the National Bureau of Standards was requested by a group of manufacturers to undertake a project which should have for its purpose the calibration of end gages to the nearest ten-millionth of an inch. This is a full order of accuracy beyond that which has been conventionally provided in the past.

I should like to emphasize that this is not an instance in which a group of dreamers dreamed up a problem in order to create difficulties that might call for interesting work and possibly result in an elegant but not necessarily very useful solution. Instead, the proposal arose from a need which had made itself apparent as a result of the precision of modern machining operations.

However, a requirement for gages good to one ten-millionth of an inch does not indicate that industry is now in a position to make parts for production purposes accurate to one ten-millionth of an inch. With work tolerances expressed in ten-thousandths of an inch it has been necessary to have master gages good to a millionth.

IN some instances modern production methods, notably precision grinding operations, can work to tolerances closer than one ten-thousandth—let us say, to a few hundred-thousandths—and immediately satisfactory control requires that our best master gages be known to one ten-millionth of an inch. That such increased accuracy can be usefully employed is a tribute to American manufacturers, to American production methods, and to the American machine-tool industry.

Dr. Gardner is chief of the Optics and Metrology Division of the National Bureau of Standards, Washington, D. C. This article was given as an address before a recent meeting of the Dimensional Standards and Metrology Division of the Ordnance Association held in Washington.

The difficulties which arise when one seeks this increased accuracy are concerned with the following: (1) The attainment of the necessary precision of measurement; (2) Variation of the wringing interval; (3) The phase change when one has reflection at a metallic surface; (4) The production of gages sufficiently precise as regards planeness and parallelism of the end surfaces; (5) Temperature control of the gage during measurement; (6) The stabilization of the gage material.

Within the visible spectrum one ten-millionth of an inch corresponds approximately to one one-hundreth of a fringe width in an interferometer. Good progress has been made in producing an interferometric system which, by averaging a few observations, gives this precision.

An achromatic prism system originally invented by Kösters and Lampe of the Deutsche Physikalisch-Technische Reichsanstalt has been built into an interferometric comparator which, with white light, permits differences of length not exceeding two ten-thousandths of an inch to be determined with a probable error of one ten-millionth of an inch.

THE present instrument is not in final form and has inadequate thermal shielding. Consequently, measurements have only been made on short blocks for which temperature control is relatively less important. A more complete instrument is now being designed. It will have adequate thermal control, and a monochromator will be incorporated in the instrument in order to permit gages to be measured in terms of wave lengths. The contemplated instrument, therefore, will permit the comparison of gages or absolute measurements of length. It will receive gages 100 mm. long or less.

When two gages are wrung together the cohesive force is the molecular attraction acting across the surface separating the two gages. Experimental work tends to indicate that when two surfaces are wrung together they are separated by approximately three ten-millionths of an inch. I refer to this separation as the wringing interval.

The length of an end gage is defined as the geometrical length plus one wringing interval, and, accordingly, many calibration procedures are de-

signed to measure this defined length automatically. As long as one is interested only in errors as great as a millionth of an inch, possible variations in the wringing interval are not of great importance, but more information concerning the magnitude of the wringing interval and its constancy is necessary for the higher accuracy now desired.

FREQUENTLY when a gage is measured, first with one end wrung down and then with the other end wrung down, small but significantly different values of the length are found. This difference in length presumably arises from a difference in the wringing interval resulting from a difference in the planeness of the two surfaces. The wringing interval will probably be different for gages of different materials and may depend upon the amount of fluid allowed to remain on the surfaces that are wrung together.

For satisfactory measurement to the nearest ten-millionth of an inch it will be necessary to make a careful study of the influence on the wringing interval of the different factors that have been mentioned. This investigation has been planned, and the solution appears to be relatively straightforward, but no data have been taken.

There is an abrupt change of phase when light is reflected from a metallic surface or from the surface of any absorbent material. This phase change may be interpreted as a penetration of the light into the surface. In many respects the error arising from this phase change is analogous to the penetration of the sensing element of a mechanical gage into the object being measured.

It is evident that the precise measurements now planned require a more precise knowledge of the magnitude of this phase change than has previously been necessary. An interferometer has been designed and built to measure phase change. In reality it measures phase change and difference in wringing interval at the same time. Consequently an independent measurement of wringing interval will have to be made in order to determine the effect of phase change.

The amount of the phase change is dependent upon the material of which the gage is made and upon the character of the surface. There is less change of phase at a highly polished surface than at a surface that contains pits or residual scratches. The Deutsche Physikalisch-Technische Bundesanstalt has used a photometric instrument to measure the amount of light scattered by a surface not perfectly polished and this has been used to give the phase change resulting from the quality of polish.

"Frequently when a gage is measured, first with one end wrung down and then with the other end wrung down, small but significantly different values of the length are found. This difference in length presumably arises from a difference in the wringing interval resulting from a difference in the planeness of the two surfaces. The wringing interval will probably be different for gages of different materials and may depend upon the amount of fluid allowed to remain on the surfaces that are wrung together."

One of these instruments has been ordered with delivery promised in six months. Upon its arrival this instrument will be studied to determine whether or not it gives results satisfactory for the greater precision of the present project.

The limiting precision with which a gage can be measured is determined not only by the precision of the measuring method but also by the precision with which the gage defines a length. If the ends of a gage are not optically flat there is a limiting precision beyond which one cannot usefully proceed because the increased precision cannot be used in the applications of the gage. According to present specifications a variation of three-millionths of an inch in parallelism and flatness is allowed in a gage one inch long.

It is evident that much better surfaces and parallelism will be required if the length of a gage is to be usefully measured to the nearest ten-millionth of an inch. A special interferometer has been built for testing the parallelism of the ends of gages because this, too, is a requirement for the more precise work. This new interferometer can be built to test the parallelism of a gage too long to be tested by the usual interferometric methods. The present instrument will test gages up to twenty inches in length, and this length can be increased.

With our improved testing methods we are confident that we can make individual gages by hand working that will be sufficiently precise for the new measuring methods. No attempt is being made at present to produce these gages on a production basis. If the National Bureau of Standards demonstrates that gages of this increased precision are useful and develops tests for the different characteristics of a gage we believe that industry, with its present proficiency in the production of gages, will be in an excellent position to develop production methods of making the more precise gages.

When a gage is to be calibrated to one part in ten million it is desirable to know its temperature to better than one hundredth of a degree centigrade. To attain this degree of temperature control requires care but presents no new problems.

It has already been noted that our new interferometer is being designed with special care to establish known equilibrium temperature conditions for the gages being measured.

FOR gages to be useful at this new higher precision it is necessary that the metal be stabilized to eliminate secular change of dimensions as much as possible. Measurements of the length of individual gages over a period of years indicate that gages differ greatly in the degree of stabilization, even for the individual gages of a single set.

Some of our gages have shown remarkable stability over a period of twenty-five years. Our measurements definitely show that gages can be satisfactorily stabilized.

EDITOR'S NOTE.—Writing in the May-June 1955 issue of ORDNANCE on the subject, "Ten-Millionth of an Inch," Dr. Gardner stated:

"The military rifle was perhaps the first precise mechanism produced on a sufficiently large scale to justify interchangeable production and hence provided an urgent need for the development of exact gaging procedures. A new program for the manufacture of Mauser rifles in Sweden under a German license was the immediate stimulus for the conception of the new gage blocks. The gaging length of each block was defined by two optically plane, parallel surfaces."

Joints for Missiles

The development of a new type of interrupted screw thread capable of high production has retained advantageous features but eliminated many manufacturing and inspection problems and allowed broader tolerances

B. Baker

A STRUCTURE might be quite efficient if it did not require joints or connections. Unfortunately, joints are required in order to manufacture the part, gain access to the contents, or to have convenient sizes for handling.

In any missile, and especially for small ones such as an air-to-air defensive missile, joints are desired for another, less obvious reason; that is, to divide the body in such a way as to segregate different types of contents which may require different storage, handling, or check-out procedures, such as guidance, warhead, and power plant.

The problem of providing an efficient, quick-operating, and aërodynamically clean joint has plagued designers for many years. Many types have been proposed, and some tried. These include torpedo joints (tension bolts on an angle), flush clamp rings, screw threads, overlapping ends with shear pins, and recessed tension bolts. Each has certain advantages and disadvantages, but none fulfilled the requirements for a small, air-to-air missile which had to be assembled in minutes.

A BREECH-LOCK type of joint appeared to fulfill all requirements for this weapon, and one was designed and developed for early research and development models. Moderate success was had when production was low and rigorous interchangeability was not a factor. However, when production was accelerated and interchangeability mandatory, technical difficulties of manufacturing and gaging were encountered which forced a change in design.

The basic function a joint must perform is to carry a load from one side to another. The obvious solution on screw threads is to bottom the shoulders. For this purpose a modified buttress thread was developed, with single lead and six pitch, views of which are shown in Figure 1.

The threads were interrupted at four points around the periphery to permit insertion of the screw into the nut, then locking against the shoulder with a one-eighth turn, similar to breech locks on artillery and shotgun barrels. Rotational indexing desired was plus or minus 0.010-inch. The thread form detail is shown in Figure 2.

Examination of dimensions and tolerances in Figure 2 will show that many are critical, especially the one indicated as *X*. During early production attempts with the buttress thread, the main source of difficulty was in determining the true value of *X* and where it should be measured rotationally in order to obtain complete interchangeability.

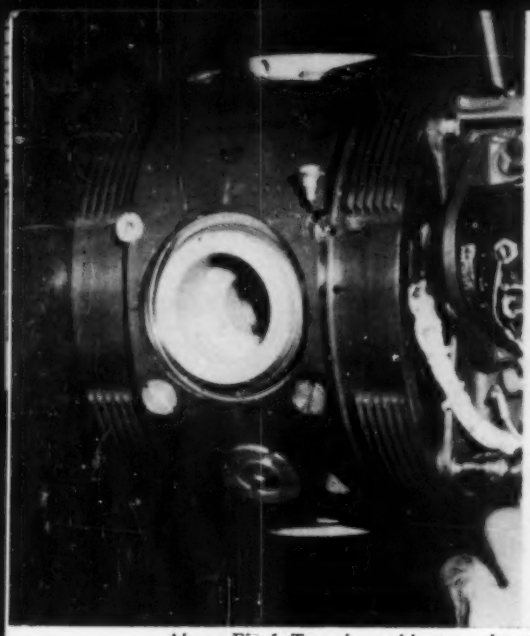
As can be seen, a slight variation of *X* affects the rotational indexing of two mating halves: on an 8-inch diameter, 0.001-inch variation allows an index variation of 0.1513-inch, assuming the torque load is the same and friction is constant. This is much greater than the desired indexing of plus or minus 0.010-inch.

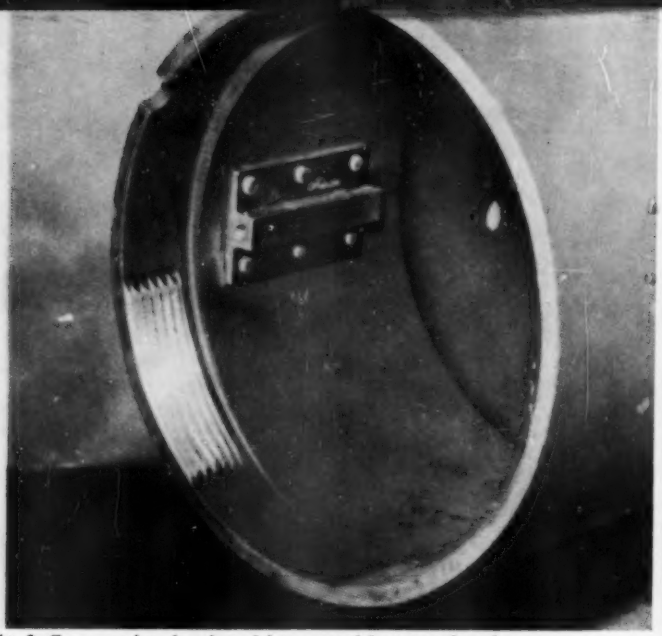
ALTHOUGH it is an accepted fact that a circumferentially qualifying thread can be done economically to only 60 degrees, and that this design required indexing to about a quarter-degree of arc, solutions to the problem were sought.

Attempts were made to control indexing by an elaborate tooling program. At least five sources of supply were involved, and therefore master gages were made to control vendor tools. It was believed that if the *X* dimension could be controlled to 0.0003-inch, interchangeable parts would result. However, best tooling practices were capable of only 0.0002-inch accuracy, or two-thirds of the part accuracy. Results of interchangeability checks with such parts indicated that only eighty per cent of parts passing one gage would pass another gage.

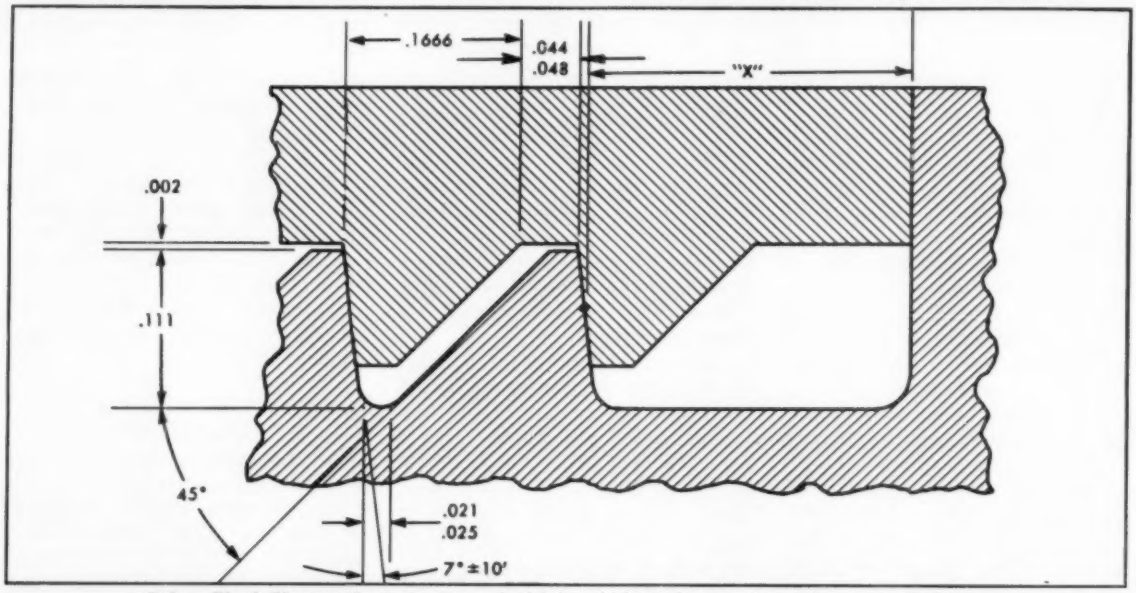
From calculations it was found that with the best accuracy possible on machinery, if parts were purposely made long they could be brought up to the index line with 500 foot-pounds of

Mr. Baker is chief of the Reliability Section, Missiles Engineering Department, Douglas Aircraft Company, Santa Monica, Calif. *This paper was presented recently before a meeting of the Guided Missiles Division of the American Ordnance Association, held at China Lake, Calif.*

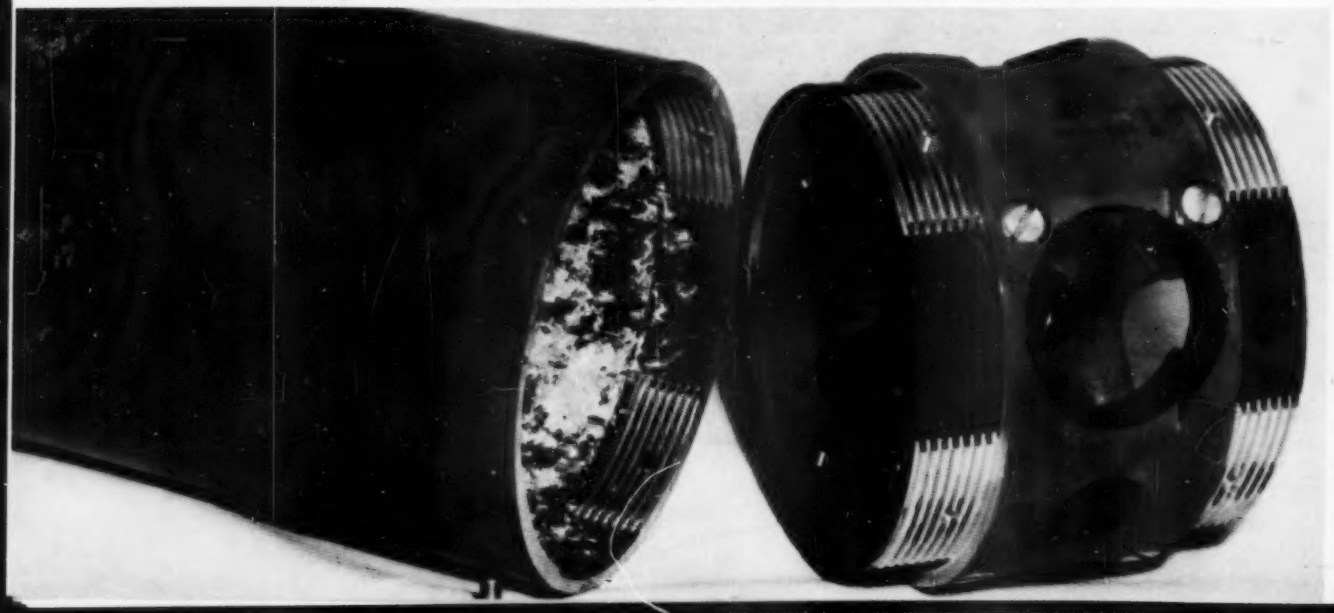




Above, Fig. 1. Two views of buttress thread joint. Below, Fig. 2. Cross-section drawing of interrupted buttress thread.



Below, Fig. 3. Photograph of an acme no-lead joint which can be manufactured on a standard lathe.



torque. As an 8-foot-long torque wrench was obviously impractical on an aircraft carrier deck, a special screw-type torque wrench was made.

Many of the procedures attempted were efforts to alleviate the basic trouble, which was incapability of machines to manufacture parts to the required tolerances. Areas of insufficiency were inability to locate the starting point of *X* on the sloped side of a helical screw, inability to hold *X* once the origins were established, squareness of shoulder which affects *X*, lack of true helix, surface roughness, and local high spots.

Various methods of obtaining *X* were tried. These included compressive set by axial loading, rolling the shoulder to elongate *X* up to the desired value, and honing each shoulder to match the gage.

On those parts successfully passing gage inspection, repeated joining of the parts resulted in a certain amount of "wear in," so that after five or six joinings overrun of the index marks was frequently observed.

A solution to the problem was to carry load through the joint by bearing on the pitch diameter instead of the end shoulder. The flexibility of nonferrous alloys with thin sections made the solution possible.

WITH a normal tolerance acme thread on aluminum or magnesium alloy shells it is possible to deform the nut to jam against the pitch diameter of the screw. This is done by four radial screws as shown in Figure 3. The thread form is shown in Figure 4. Shoulder fit is no longer required, and nominal clearance is provided to allow for axial manufacturing tolerance.

This acme thread does not have a lead angle, which permits manufacturing on a standard lathe with either a form tool or a single-point tool. This form tool is satisfactory on aluminum and magnesium parts, but excessive chatter occurs on steel parts, and a single-point tool is preferred. Hobbing has not been very successful due to minute flat spots caused by tooth spacing, which affects the pitch diameter fit.

Gaging for the acme thread amounts only to a standard roller-type snap gage (Tri-Rol) for pitch diameter, a go, no-go for major diameter, and go, no-go for minor diameter.

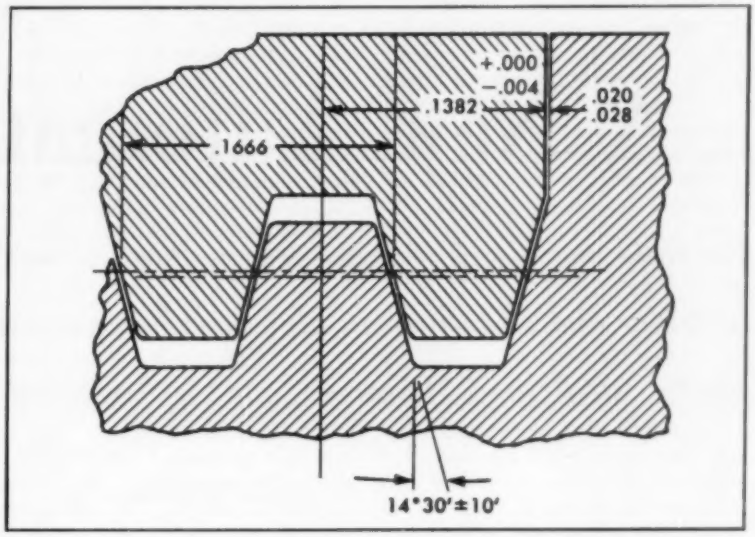


Fig. 4. Cross-section drawing of an acme no-lead thread.

The manufacturing sequence, abbreviated, is:

(1) lathe profile tube ends, (2) breech on Plan-O-Mill, (3) form tool threads on lathe.

Engagement on the pitch diameter proved to have an additional advantage over the shoulder engagement in that more material is in contact. At least half of each thread segment is in tight contact, as compared with one-or-two point contact in the buttress thread, permitting a structurally tighter and stiffer joint. The natural bending frequency of the missile is therefore higher and control response is better.

Comparison of the two types of joints indicates advantages of no-lead acme thread.

	BUTTRESS THREAD	*ACME THREAD*
1.	Special production fabrication methods and procedures are required to hold the close tolerances required.	Standard shop methods and procedures used in fabrication.
2.	Thread and shoulder are cut in separate operations.	Thread and shoulder are cut in same operation, thereby insuring uniformity.
3.	Tools are fabricated to 0.0003-inch tolerance.	Tools are fabricated to 0.002-inch tolerance.
4.	Interchangeability controlled by tool masters and inspection gages.	Interchangeability controlled by engineering print.
5.	Inspection gages required to inspect all thread joints—male and female.	Standard inspection thread gages, wires, and procedures used to inspect acme no lead thread.
6.	Special tooling required for tool masters, inspection gages, and production.	Cutters (hob) for standard acme thread form, easily available for production.
7.	Special crank-type torquing tool required for assembly of components, in field, etc.	No special tooling required (standard large screwdriver only).
8.	Field rework difficult in most cases.	No field rework.
9.	Extremely flexible joint.	Stiff joint.

A New Automatic Rifle

Fairchild has developed a 7-pound, 20-shot weapon using the 7.62-mm. cartridge and employing an aluminum receiver-frame and housing, a foam-plastic stock and forearm, and a simplified gas-actuated mechanism

Melvin M. Johnson, Jr.

Colonel Johnson, U.S.A.R. Inactive, is the distinguished inventor of Johnson arms. He is currently serving as consultant on research to the Operations Research Office of Johns Hopkins University and in a similar capacity to several industrial organinzations including the Fairchild Engine and Airplane Corporation.

DURING World War II our ground forces carried 2.50-pound pistols, 8-pound submachine guns, 5.50-pound carbines, 9.75-pound semiautomatic rifles, and 21-pound automatic rifles. About 1945 the Army initiated an investigation of the merger of four or five of these models into one 7-pound full- and semiautomatic 20-shot rifle which, with heavier barrel for sustained fire and bipod for prone stability, also would serve to replace the 21-pound Browning automatic rifle, caliber .30, M1918A2.

The Army sought a suitable semiautomatic rifle since the early twentieth century, and there were several auto-rifles by that time, however clumsy. The pistol-cartridged submachine gun goes back forty years, the low-powered carbine close to two decades, the U. S. M1911 pistol over half a century, and present caliber .30 ammunition over fifty years.

The "family" of semiautomatic rifle and, with modification, auto-rifle was seen by 1941 in the Johnson semiautomatic rifle and light machine gun.

FOR over the past twenty years, with few exceptions, there has been little inventive activity in arms by American industry. Army Ordnance arsenals have had to carry the brunt of creation and conception. Industry has performed chiefly advanced engineering and production.

All U. S. ground and aircraft caliber .30 and .50 machine guns stemmed from John Browning's original 1900 patents, the U. S. M1911 pistol and M1918 auto-rifle from early Browning patents, the M1928 submachine gun from Thompson (Payne) patents, the M1 carbine of 1941 from Ordnance development contracts with Winchester, the M1 rifle from 1927-1936 Ordnance development, the M3 submachine gun from Ordnance World War II origination. (The Johnson weapons were of 1936-1941 private design.)

About 1934 a special Senate committee investigated U. S. munitions manufacturers who were charged with promoting war for profit. This committee was headed by Senator Gerald P. Nye and counsel for the committee was Alger Hiss. In my opinion, based on some study, this "munitions-monger" hue and cry had a major adverse influence upon American military arms development.

At the same time the Baker Board report on military aviation recommended full recourse to the American aircraft industry for competitive development, even stating that the Government should not build airplanes.

During the light automatic rifle development period of 1945-1956 the only U. S. weapons noted were the rear-locked gas-operated T25-T47 and M1-T20E2 modified T44, both using the earlier White gas-expansion system of about 1925. These were both of Ordnance Springfield Armory design. The T47 eventually was dropped in favor of the T44.

ABOUT 1950 the British Ordnance introduced their EM2 caliber .280 rifle and Fabrique Nationale of Belgium submitted their FN (later designated the T48). Intensive debates developed over these rifles, more especially as to the merits of the British 2.50-inch caliber .280 cartridge versus the U. S. shortened caliber .30 T65E3 ammunition, 0.55-inch less in loaded length than the 1906-1956 3.35-inch caliber .30 still standard in our service today.

Following the highest-echelon NATO controversy, the U. S. shortened .30 cartridge, now NATO 7.62-mm., and the U. S. T44 and Belgian FN T48 rifles emerged and continued on for further Army extended engineering, field, and troop trials.

Publicity of FN-T48 details disclosed and inevitably evoked press emphasis over the similarity of the FN-T48 and the Russian Tokarev Model 1938 mechanism. The Tokarev U.S.S.R. semiau-

tomatic rifle was dropped by the Soviets about 1944, apparently for failure under combat conditions.

Much stress was placed upon FN field-stripping features, with break-open butt takedown.

As field tests continued, the need for strip-clip loading was noted because 20-shot T44-T48 steel magazines weighed 0.60-pound each, the T44 rifle some 8.50 pounds, the T48 about 9 pounds, and the M1 9.75 pounds. With 160 magazine-loaded rounds the total loads were, approximately: M1, 18.75 pounds; T44, 21.30 pounds; T48-FN, 21.80 pounds.

With its receiver opened topside for strip-clips the FN developed some field-condition troubles comparable to the basically open-breeched M1-type T44.

AMONG some half dozen divisions of the Fairchild Engine and Airplane Corporation is Armalite of California. This unit has had especial support from Fairchild's pilot (ex-Army Air Corps) president and small-arms expert Richard S. Boutelle. The highly heralded C-123 700-foot take-off and landing transport (Airborne) airplane is one of many accepted Fairchild contributions to national defense. Now, Fairchild has submitted a 7-pound light automatic 20-shot rifle, caliber 7.62-mm., using the NATO cartridge.

The 40-inch Fairchild AR-10 rifle embodies a front-locked, 8-lug, 22.5-degree (Johnson-type) turn bolt system, gas-pipe actuated, which localizes maximum circumferential locking strength of bolt and barrel abutments within minimum space for minimum weight, especially as compared with the rear-locked T47, FN-T48, and frame-locked M1-T20E2-T44.

Therefore, it is practicable in the Fairchild firearm to use an aluminum receiver-frame and housing, a principal weight-cutting design conception.

For many years designers of gas-operated arms have sought to simplify fragile elongated operating rods and gas cylinders and pistons which are complicated to fabricate, clumsy to clean, and sensitive to abuse. Fairchild uses a fixed gas pipe, seen earlier in rear-locked French and Swedish 9-pound rifles. The Fairchild gas take-off is tubed from abaft the muzzle into a hollow port-side piston section of the bolt carrier. The gas tube, port location, and bolt mass delay unlocking until chamber pressure has dropped.

Gas passing through the pipe drives the bolt carrier rearward, making the one basic breechblock assembly serve two fundamental functions—unlocking the 8-lug bolt and opening the breech. Thus, the versatile breechblock assembly also serves the system as the gas piston cylinder.

Through the bolthead cam stud and carrier cam track the piped gas cams the bolthead, produces primary extraction, drives the one-pound bolt unit rearward, cocks the hammer, compresses the straight-line main spring, permits spring-load ejection, and magazine feed return.

BECAUSE the gas component is also the breechblock, complete cleaning requires only release of one locking pin and manual withdrawal of the breechblock assembly. There are no other action parts to disassemble. The hammer mechanism is opened in the same operation. Thus, field stripping and cleaning are exceptionally simple and unusually fast.

In combat the Fairchild moving mechanism is completely enclosed on all sides, the ejection port being protected by a hinged cover such as may be seen in the reliable Ordnance M3 "mudbath" submachine gun.

The 20-shot corrugated aluminum box magazine weighs some 3.50 ounces. Thus, 160 rounds loaded in magazines

Right and left side views of the new lightweight 40-inch Fairchild AR-10 rifle now being tested.

weigh less than 10 pounds, the total soldier's load of rifle and ammunition being less than 17 pounds.

The 1.50-pound alloy-steel barrel, longitudinally fluted at the breech end for radiation and rigidity, is housed in an air-cooling apertured foam-plastic forearm. (T44-T48 barrel weight is some 0.20-pound more than the Fairchild. Thus, with T44-T48 barrel the Fairchild would weigh only 7.20 pounds.)

The straight-in-line butt stock with in-line large diameter mainspring is especially suited for fast semiautomatic and full-automatic fire. Unlike the more conventional "drop" stock, the Fairchild straight foam-plastic stock resembles that of the Johnson M1941 light machine gun, the German MG34 and 42, Fallschirmjaeger Gewehr 42-44, U. S. T25 rifle, and the T161 machine gun. Straight-line stocks produce less jump and climb. Less inconvenience from barrel heat mirage is experienced from the attendant high line of sight.

The Fairchild is equipped with a 6-ounce muzzle brake and flash supressor, giving some forty per cent recoil relief. Equipped with a rubber butt pad and with the brake removed, the rifle would weigh only 6.65 pounds.

The Fairchild "family" includes an aluminum-radiator quick-change heavy-barrel bipod auto-rifle version at about 10.50 pounds. Both versions have winter triggers and full-semi-safe fire controls.

"For over the past twenty years . . . there has been little inventive activity in arms by American industry. Army Ordnance arsenals have had to carry the brunt of creation and conception."

The briefcase carrying handle combines three functions. It houses the adjustable peep sight, serves as a carrying convenience, and protects the topside-mounted cocking handle adapted equally to right- and left-handed operators for initial charging.

Based upon considerable observation and several hundred rounds of personal firing, the writer, on December 7, 1956, found the Fairchild on semiautomatic capable of a rate of over 80 shots a minute, putting 40 aimed shots inside 10 inches at 100 yards in half a minute, slow-fire groups in 4 inches. The rifle functioned with 110, 150, 160AP, 180-grain loads at all angles, all positions, held loose, and fired in one hand semiautomatic and full automatic.

It was possible to hit vertically hand thrown tin cans even with the high hooded front and peep sights. From my observation the rifle appears outstanding in its reliability over any probable combat endurance life, in severe abuse under rain, mud, dirt, dust, sand, and extreme conditions of climate.

In my opinion, any technical or field-user changes desired in this weapon as I have fired it would be of a minor nature, and it has at least 10,000-round life. Moreover the rifle appears capable of firing 600 rounds within half an hour without interruption, cleaning, or oiling. The weapon appears sufficiently air-cooled not to "cook off" after such extended firing.

BECAUSE of its simple basic engineering design, elimination of operating rod, its front-locked breech, and advanced adaptation to the most modern materials, the writer anticipates a high order of simplicity and economy in the mass production of this rimless conventional-cartridged 7-pound weapon. It represents a significant combination of American industrial endeavor, aircraft, aircraft engine, and weapon engineering know-how and go-do.

At this writing the Fairchild rifles are under study by the Army.

With few parts to disassemble, field stripping and cleaning of the Fairchild rifle are extremely simple and fast.

Power Spinning Techniques

A new method has been developed for forming conical and tubular metal parts by the use of exceptionally heavy pressures to create a high percentage of plastic deformation in the material thus being shaped

John N. Heater

A BRAND-NEW method of metal forming is taking its place today among our manufacturing enterprises—one which has been undergoing intensive development for the past five years in the laboratories of several machine-tool builders and their customers. Known by various names—roll forming, power spinning, floturning, hydrospinning and others—it is essentially a spinning technique where exceptionally heavy pressures are employed to create a high percentage of plastic deformation in the material being formed.

At Cincinnati Milling Machine Company this new method is called "hydrospinning" because our machine is largely hydraulically actuated, as is true of our Hydroform deep-drawing machines, our Hydromatic and Hypowermatic milling machines, and many of our other machine tools.

Power spinning is uniquely individual and should never be confused with hand spinning as commonly practiced today. Power spinning is as different from hand spinning, in its basic concepts, as cold extrusion is different from deep drawing of sheet metals.

SOME of the basic principles which underlie our present-day techniques were discovered in the nineteenth century and have been in constant use since then. It took the exacting demands of this era of jet engines and guided missiles to bring into sharp focus the unique advantages of power spinning.

Mr. Heater is western field engineer for the Process Machinery Division, Cincinnati Milling & Grinding Machines, Inc., Cincinnati, Ohio.

Certain of the jet engine manufacturers early learned of a technique called shear spinning and immediately sensed its possibilities as a superior process for production of many conical, tubular, and curvilinear lightweight, highly stressed parts about which they were concerned.

The rocket-powered missile, in its size and complexity, presented new and unorthodox manufacturing problems from nose cone to exhaust cone that suggested possible solution by power spinning. So it has been these very real needs that brought power spinning forth as a new, promising, and tremendously interesting metal-forming process.

More specifically, power spinning is a method whereby very large reductions of material thicknesses can be accomplished by cold plastic deformation to produce surfaces of revolution. Primarily it is the ability to redistribute metal from a compact, heavy preform to a final part configuration with shapes, physical properties, and tolerances that would be difficult or impractical to produce by any other means.

In effect, it enables the formation of a part by *moving* instead of *removing* metal. Resulting advantages include reduction of tedious machining hours, reduction of costly direct labor operations such as hand fabrication and welding, and reduction of metal loss in the form of chips, a wasteful depletion of our resources where quantities of critical materials are involved.

WE classify the hydrospinning technique into three broad categories—shear spinning, tube spinning, and contour spinning. Fundamentally, shear spinning produces conical parts from flat disks and adheres closely to a principle known as the "sine law." The sine law states that the finished cone wall thickness is equal to the flat blank thickness times the sine of one-half the included cone angle.

Tube spinning technique is most often applied to the manufacture of precision, seamless, thin-wall tubing from shorter, heavier-wall, ring-shaped preforms. This is essentially a process of continuous point extrusion. Like shear spinning, maximum reductions of material thickness are largely a function of machine force capacity and material ductility. As an indication of tube-spinning potential, multiple passes have produced thickness reductions of 90 per cent without intermediate annealing in AISI 4130 steels, and of 75 per cent in AISI 52100 steels.

As a general guide in shear spinning and tube spinning, the maximum preform wall thicknesses we have success-

fully worked with in steels range up to approximately three-quarters of an inch.

Contour spinning simply involves the use of cross slide tracer control to permit spinning of curvilinear shapes which depart from the essentially straight-line processes of shear spinning and tube spinnning. Contour spinning may embody the underlying principles of either tube or shear spinning or both. It also enables us to utilize the functional operations of conventional hand spinning if desired.

FOR example, a missile nose is essentially a shear-spinning operation except that contouring must be employed to produce the curved, streamlined shape. On the other hand, a tubular section may have external stiffening rings which may be deposited during spinning by tracer action.

As you might expect, materials must possess a good degree of strength and ductility to qualify for processing in this manner. Even so, experience has shown that some metals not so readily formed by drawing or machining do exhibit a higher degree of formability by power spinning.

Most mild to high alloy steels qualify well. Of course, as carbon content increases so must the percentage of alloy with other metals to produce a grain structure which will withstand the high degree of compressive plastic deformation without failure. We believe that ferritic and pearlitic structures readily deform in a plastic manner, whereas coarser iron carbide lamina are fractured and redistributed in the highly oriented structure of the cold-worked section.

Frequently it is desirable to subject high-carbon alloy preforms to a spherodizing anneal before spinning to place the free carbide in its most easily worked form.

The series 200, 300, and 400 stainless steels all seem to exhibit a good degree of formability in power spinning. However, maximum percentages of cold reduction are not generally as high as with other steels.

Most wrought-aluminum alloys spin well. Much work is currently being done with spinning of aluminum alloys immediately after heat treatment where full hardening occurs by aging after spinning.

Work with materials such as titanium, magnesium, and molybdenum indicates that they must be spun hot and that temperature control of work and tooling is important. On hydrospin equipment it is possible to use flame heating as the work is spun.

Metals for hydrospinning through heavy reductions must be essentially free of such defects as laps, seams, and inclusions. Defects from the foundry or rolling mill will be quickly exposed by failure through those defects which cannot withstand extreme cold plastic deformation.

These same considerations hold true where welding is employed to produce preform shapes, which is often the case. Such welding must be of the highest quality and absolutely sound. Any slag inclusion or voidage in the welded structure will surely cause failure under deformation of this magnitude. By the same token, hydrospinning will proof-test a welded joint, for if it stands up through these types of power spinning operations it is safely assumed to be as good as the parent metal.

For the most part, physical properties of a material are greatly enhanced by a cold-working process such as hydrospinning, a direct result of grain orientation and refinement. Cold plastic deformation of a metallic crystalline structure, by virtue of a compressive force system acting upon it, results in a marked and characteristic grain orientation in the direction of flow, parallel to the part wall and axis. There is an accompanying major refinement of structure.

Such orientation and refinement contribute greatly to increased physical strength of the material. Subsequent annealing, or operation at temperatures below critical transformation ranges, will reëstablish the essentially random grain orientation of the original metal, except that it will be of considerably finer size than that exhibited by wrought material before spinning.

DIMENSIONAL control in hydrospinning is largely a result of using accurately made, hardened spinning mandrels, and of performing careful machine setup.

Bidirectional variation on inside diameters may range from 0.002-inch to 0.010-inch. On certain applications, considerations of material formability, feeds, speeds, amount of reduction in spinning, and roller design may all have an appreciable influence on how well the part maintains confirmation with the mandrel surface. Currently, such variables are being resolved empirically.

Wall-thickness variations hold generally within the range of 0.001- to 0.005-inch and are largely a function of setup accuracy.

We have been afforded the opportunity to study many different designs of rocket boosters, motors, and missile elements. From these, we and our customers have selected certain parts for experimental production by hydrospinning. We have spun solid propellant booster tubes in several sizes. Some of these programs have been carried through to successful test firings. We have spun rocket motor exhaust cones for certain of the larger motors and a complete rocket motor venturi for a smaller missile booster by using hot-spinning techniques.

ON missile airframes the case is similar. We are currently doing development work on a 3-piece missile skin which extends from the nose around the ogive. Already we know that production of cylindrical skin sections presents no major problem to hydrospinning.

Because of the particular nature of the power-spinning techniques, and because of their several distinguishing characteristics, it is of considerable importance that designers and production executives become aware of this process and its underlying principles so that full benefits may be realized from its several superior advantages. Production planning can then be done at the proper time—the time the item is designed.

Important and valuable progress is continually being made in this new field of power spinning, but with each major accomplishment wider horizons for new investigations are constantly revealed.

There is no doubt that the fundamental techniques which are today being studied, applied, and perfected will tomorrow comprise the elements of a commonly accepted production metal-forming process.

We know, too, from evidences of active current interest, that power spinning will play a major rôle in the manufacture of jet engines, rocket motors, and guided missiles.

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—President Eisenhower

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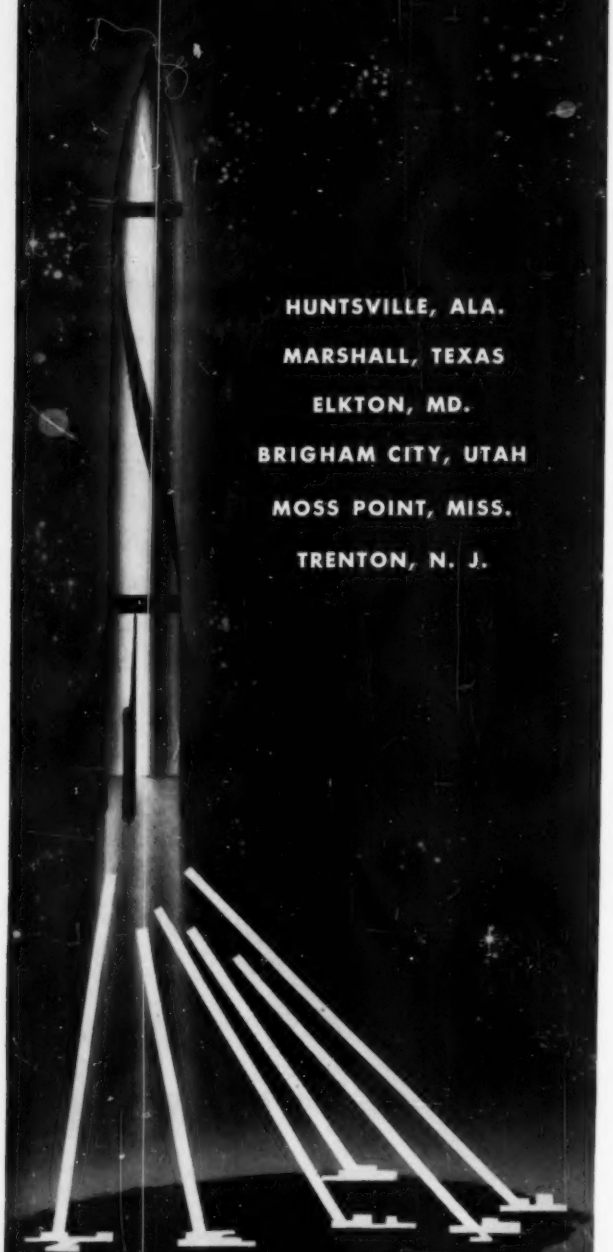

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MAY-JUNE 1957

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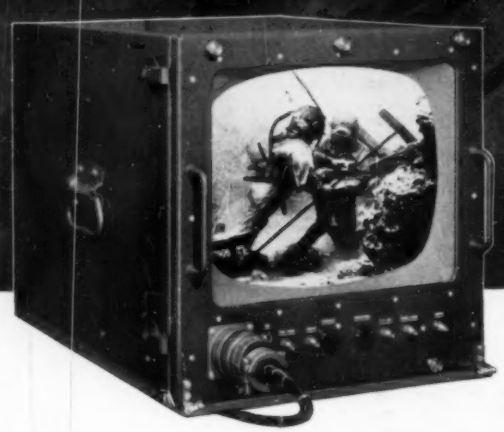

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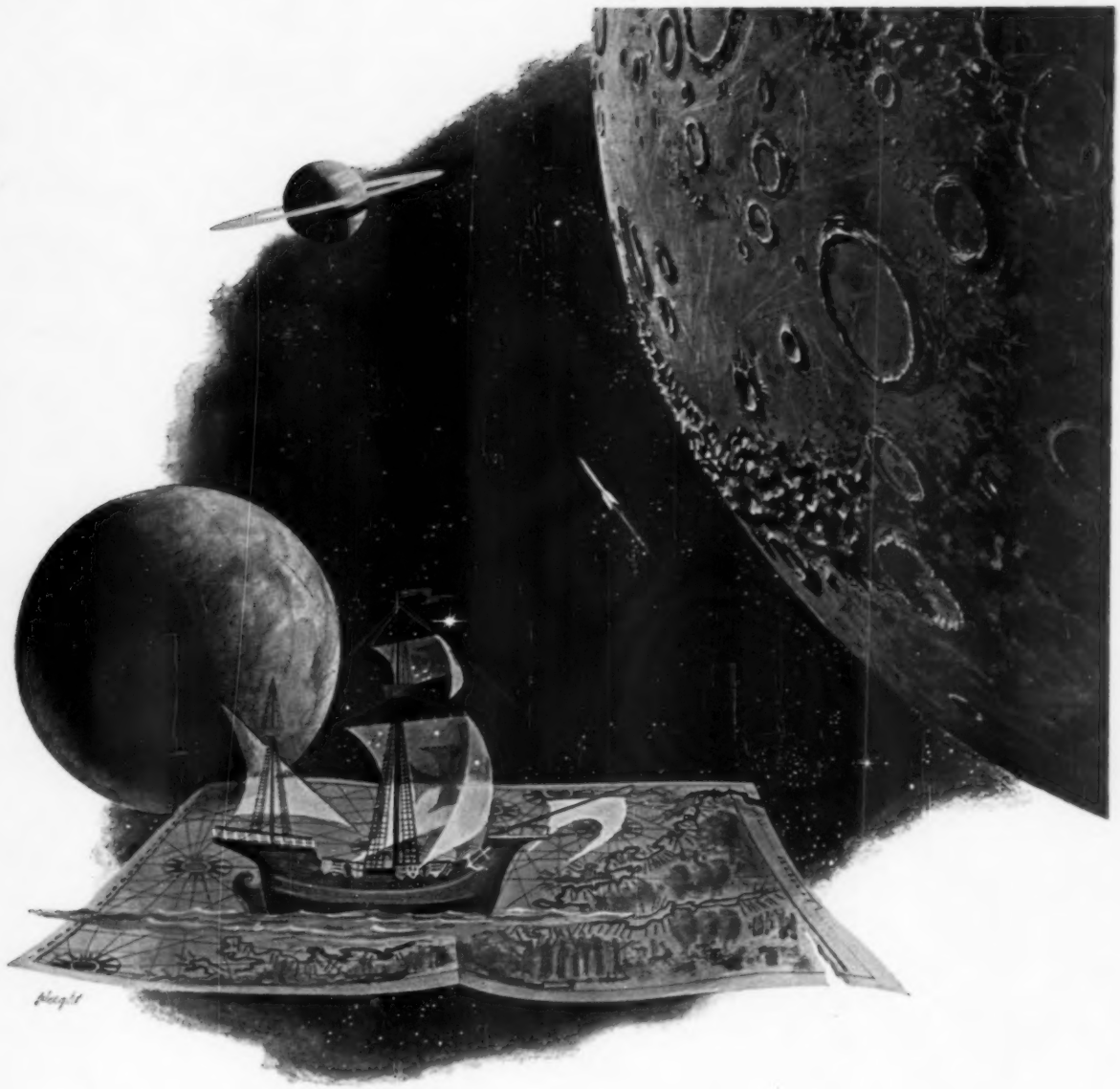

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